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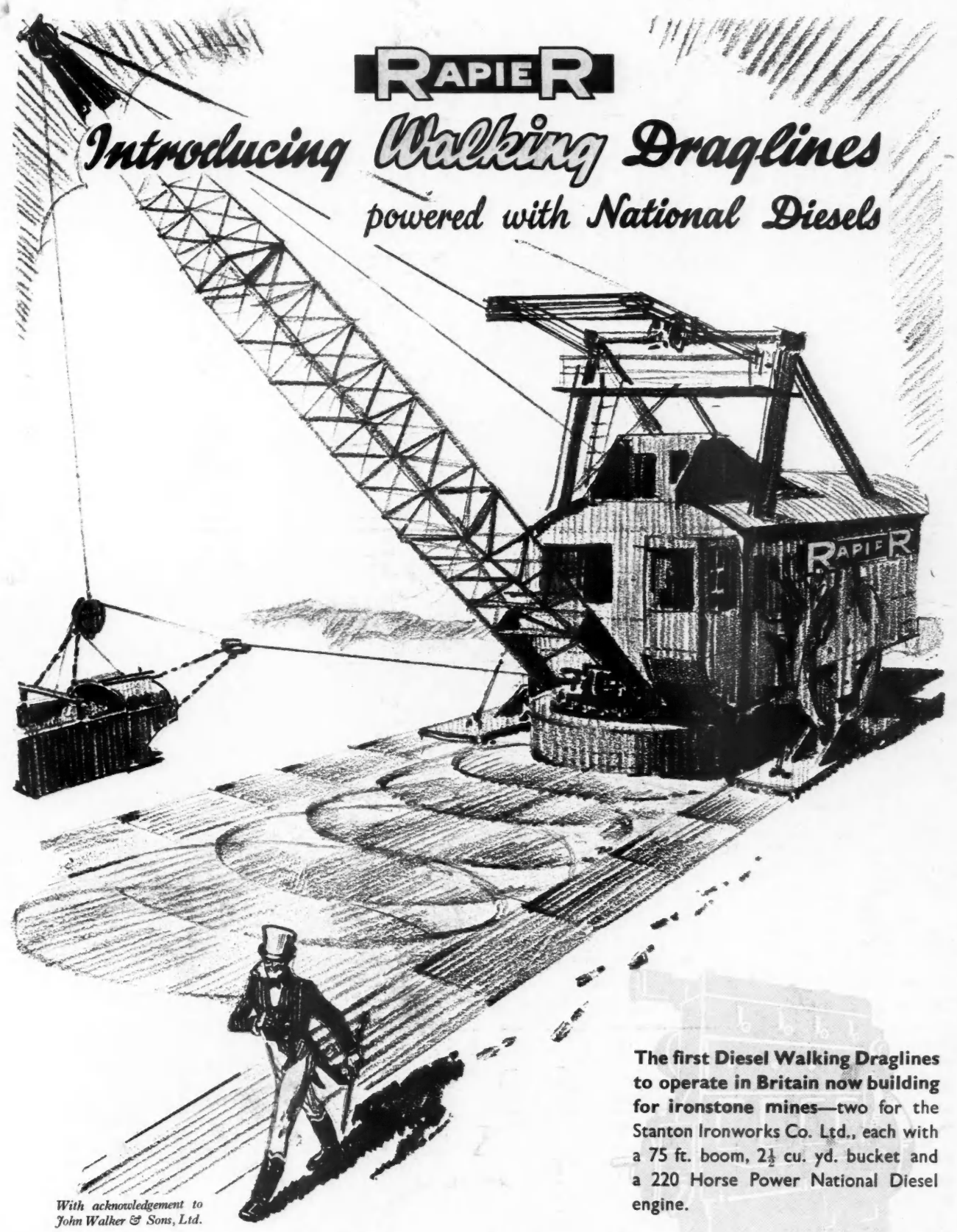

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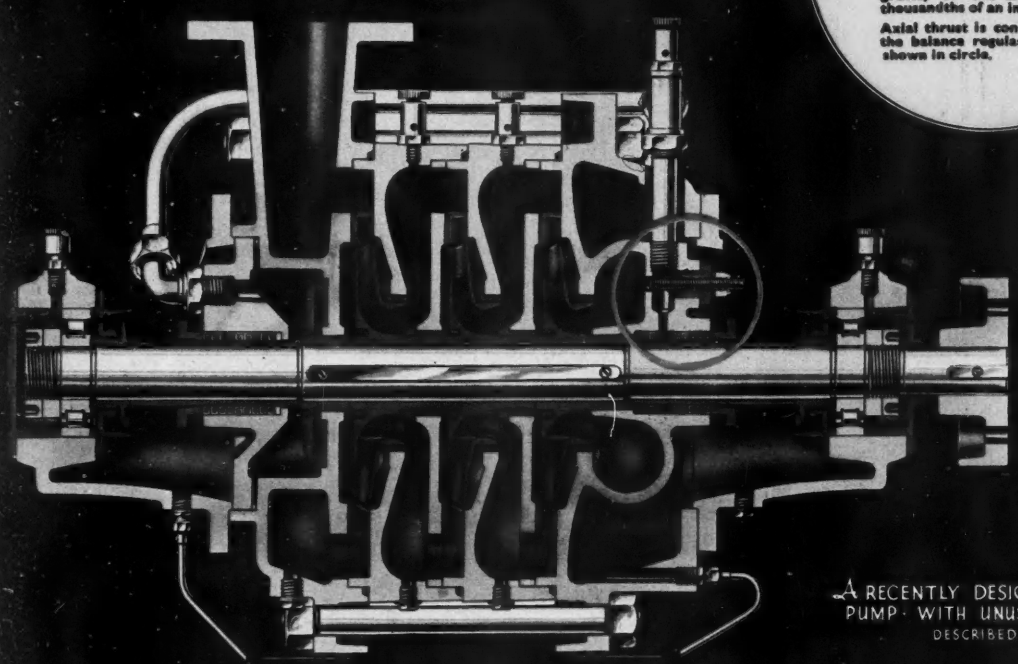

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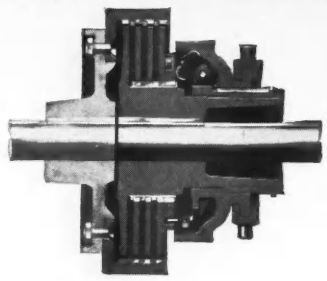

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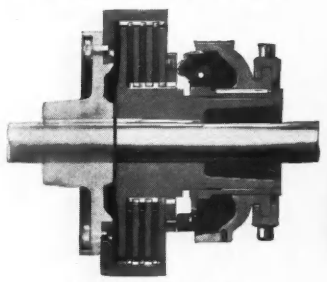

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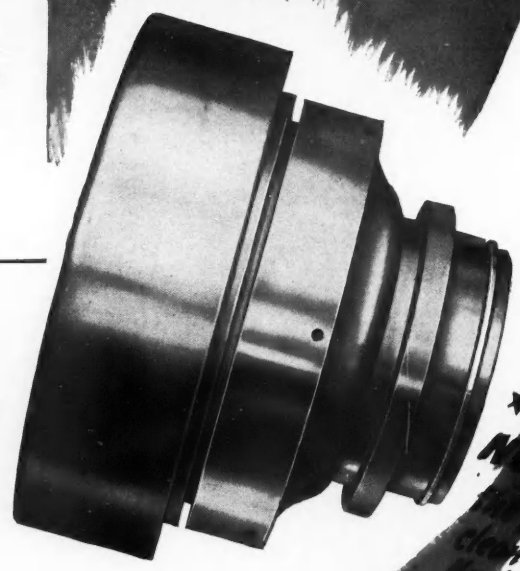

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Alternative Materials for Air Raid Shelters

THE Ministry of Home Security has approved certain alternative materials for air raid shelters under the provisions of paragraph 2 of the "Revised Code of Air Raid Shelters for Persons Working in Factories, Mines, and Commercial Buildings" (Statutory Rules and Orders, 1939, No. 920). Paragraph 2b (iv) of the Revised Code prescribes construction for overhead protection. The Minister has approved the following alternative construction under this paragraph:—"Hollow type construction, in which are incorporated hollow tiles, hollow concrete blocks, or precast reinforced concrete structural units, provided that:—(*a*) It has been designed for its normal structural purpose in accordance with the Code of Practice for the use of Reinforced Concrete in Buildings prepared by the Reinforced Concrete Structure Committee of the Building Research Board, or in accordance with the appropriate building regulations at present in force, to carry safely a superimposed load, in addition to its own weight, of not less than 50 lb. per square foot of covered area; and (*b*) it has, above the system of tiles, blocks, or precast units, not less than 3in. of reinforced concrete, or alternatively, not less than 2½in. of reinforced concrete together with a superimposed screening not less than 1in. thick." Paragraph 2 (*a*) of the Revised Code relates to lateral protection, and the following alternative special construction has been approved:—"Walls, 18in thick, built with precast rectangular hollow blocks of cement concrete, having overall dimensions approximately 18in. by 9in. by 9in.; the walls and central web of the blocks to be at least 2in. thick, and the cavities filled with ballast, shingle, earth, or sand; the blocks to be bedded in a suitable mortar, which may be of a non-hydraulic lime and sand to facilitate the recovery of the blocks if and when the wall is no longer required. The quality of the concrete to be such that the compressive strength of the blocks, tested at 28 days with the cavities unfilled, is not less than 1500 lb. per square inch calculated on the net area of the walls and central web of the blocks, and a test certificate must be provided if required."

An American Compliment to British Engineers

A VERY interesting ceremony took place on Thursday, April 25th, at Grosvenor House, when His Excellency the American Ambassador, Mr. Joseph P. Kennedy, was the guest of the Councils of the Institution of Civil Engineers and the Institution of Mechanical Engineers at luncheon. There were no other guests. After luncheon, Mr. Kennedy presented to Mr. W. J. E. Binnie the diploma of Honorary Membership of the American Society of Civil Engineers, and to Mr. E. Bruce Ball the equivalent diploma of the American Society of Mechanical Engineers. It will be recalled that Mr. Binnie and Mr. Bruce Ball were the Presidents of the two Institutions last year and were to have led their respective members on the joint visit to America which had been arranged, but which was cancelled on account of the critical situation in August. Sir Clement Hindley, President of the Institution of Civil Engineers, who was in one of the chairs at the luncheon, remarked that whilst that was the first time the two Councils had taken luncheon together he hoped it would not be the last, a hope which was endorsed by all present.

Engineer Officers for the Royal Air Force

THE Air Ministry announces that the Royal Air Force requires a number of technical officers for employment on engineering, armament, and signals duties. Commissions in the Royal Air Force Volunteer Reserve will be granted for the duration of hostilities to suitable applicants between the ages of 21 and 50 years possessing the requisite personal and technical qualifications. Candidates who possess the requisite qualifications and who are selected for commissions will be entered in the newly formed Technical Branch of the Royal Air Force Volunteer Reserve in the rank of Pilot Officer on probation. They will be eligible for confirmation in their appointments and for promotion to Flying Officer after one year, if recommended. Flying Officers will be promoted to Flight Lieutenant after three years' service as Flying Officer, if recommended. Candidates whose qualifications do not reach the high standard required of officers of the Technical Branch, but whose services can be utilised on "special duties" of a technical character may be offered commissions in the Administrative and Special Duties Branch of the Royal Air Force Volunteer Reserve. Entrants into this branch will receive the rank of Acting Pilot Officer on probation (if requiring initial training) or Pilot Officer on probation (if suitable for immediate posting to a service unit). Acting Pilot Officers will be regraded as Pilot Officers on posting to a service unit on completion of training. Pilot Officers will be promoted to Flying Officer after one year's service as Pilot Officer, if recommended. Promotion beyond Flying Officer will be by selection. Candidates should apply at once, in writing, to the Air Ministry, S.7.e.5., Adastral House, Kingsway, W.C.2, giving full particulars of their qualifications, training, and experience. Candidates who are engaged on the production of aircraft, engines, or accessories, or on other important national work, should not submit applications without first consulting their employers as to the possibility of their being spared for Royal Air Force duty.

French Battleship "Richelieu" Completed

ON Thursday, April 25th, it was reported from Paris that the new 35,000-ton French battleship "Richelieu" is now ready for active service. Quite recently Monsieur Campinchi, the French Minister of Marine, announced that rapid progress was being made with the completion of the sister ships "Richelieu" and "Jean Bart," and that the work on the four new battleships of the "Richelieu" class was being greatly speeded up. The "Richelieu" was laid down at the naval yard of the Ateliers et Chantiers de la Loire at Saint Nazaire on October 22nd, 1935, and was constructed in a dry dock. The ships of this class are intended to form a homogeneous squadron with the "Dunkerque" and the "Strasbourg" and have a designed displacement of 35,000 tons, a length of 794ft., a beam of 108ft. 3in., and a mean draught of 26ft. 6in. The percentage of displacement devoted to armour is higher in the "Richelieu" than in the first two ships, and includes an 8in. to 16in. belt, and 8in. deck armour for upper and lower decks combined. The weight of armour is given as about 15,000 tons with propelling machinery about 3000 tons. The armament comprises eight 15in. guns, fifteen 6-in. guns, and eight 37 mm., and ten 13 mm. anti-aircraft guns. Four aircraft with two launching catapults are carried. The propelling machinery consists of geared turbines taking steam from high pressure Indret boilers of which there are six in number. The machinery has a designed output of 155,000 shaft horse-power, corresponding to a speed of over 30 knots.

Accidents in Factories

CORRESPONDENCE has recently taken place between Mr. Ernest Bevin, the Secretary of the Transport and General Workers' Union, the Prime Minister, and Sir John Anderson, Minister of Home Security, on the growth of accidents in factories since the outbreak of war. The claim of the union is that such growth has been accentuated by long hours of work, excessive overtime, introduction of inexperienced workers, and the black-out. The lighting and ventilation of factories, especially during the summer months, was also mentioned. In his reply, Sir John Anderson states that the Government has prominently in mind the importance of avoiding the mistaken policy of attempting to increase output by excessively long hours. The Supply Departments and the Ministry of Labour are consulting with the Minister to see what further steps can be taken. On the subject of factory lighting, the Factory Department holds the view that good lighting is essential for the prevention of accidents, and factory inspectors are giving special attention to this matter. The departmental committee on the lighting of factories is making a special study of the question of what can be done to improve lighting under wartime conditions, and already considerable progress has been recorded. Similar progress has been made in the matter of factory ventilation. A further pamphlet for the guidance of factory occupiers on this subject is being issued, and the Department's policy for the improvement of factory ventilation is being pressed forward. From the figures which are available it seems doubtful whether the increase in accidents since September last is proportionately greater than the increase in the numbers employed, coupled with the increased number of hours for which work is going on. This, however, the Minister says, is no reason for any relaxation of the efforts for preventive measures.

Proposed Teesdale Water Power Scheme

AT a recent meeting of the South-West Durham Development Board a report prepared by Mr. G. F. Kennedy on the potentialities of the Cauldron Snout waterfall at the head of the River Tees for the generation of electric power was considered. By permission of Lord Barnard the reaches beyond the waterfall have been surveyed. The catchment area extends over 20 square miles, and will, it is stated, provide a plentiful supply of water at the necessary head. It is proposed to construct an 8ft. concrete dam, which it is claimed will increase the natural storage by a further two and a quarter million cubic feet, making a total of nearly 4,000,000 cubic feet. With the hydro-electric scheme proposed it is hoped to generate an approximate output of two million kilowatts per annum. Both the dam and the pipe line with its duct or protective tunnel could be made to harmonise with the surrounding country. The proposed plant would comprise a turbine of the twin-impulse 21in. diameter wheel type coupled to a 150 kW alternator. The initial outlay is estimated at £29,000, and the annual overhead and maintainance costs of the scheme, which with automatic control would only need the services of one regular attendant, are such as are calculated to yield current at an average cost of a farthing a unit. The scheme put forward makes provision for payment of interest at 4 per cent. and the redemption of the capital on a 40 years basis. The Development Board has decided to bring the scheme to the notice of the Government, emphasising the possibilities of the South-West Durham area, in the production of calcium carbide and the development of other minerals needed for the rprosecution of the war.

Catalagzi Power Scheme, Turkey

IT is now possible to give details of a contract which has been signed between the Turkish Government and a British engineering firm. The contract is between the Turkish Government institution known as the Eti Bank and the Metropolitan-Vickers Electrical Company, Ltd., and it covers an electrification scheme including the construction of a power station at Catalagzi, on the Anatolian coast of the Black Sea. The order has a value of approximately £1,500,000. The scheme has as one of its main objects the provision of electric power for the modernisation and expansion of the Turkish coal industry and the site of the station has been chosen for its proximity to the Zonguldak coal basin, from which the station fuel will be derived. The present contract includes the building and equipment of a 60,000 kW power station, and the provision of switch gear, overhead line, and three sub-stations for a transmission system about 16 Km. in length. Provision is to be made for extension of the scheme at some future date. The principal sub-contractors to the Metropolitan-Vickers Electrical Company will include:—Babcock and Wilcox, Ltd. for boiler and coal handling plant; Holloway Bros. (London), Ltd. for buildings and civil engineering work, including cooling water intake; and British Insulated Cables, Ltd. for overhead transmission line and cables. The initial generating plant will consist of three 20,000 kW turbo-alternator sets to operate at 3000 r.p.m. with Metrovick central-flow condensers and four-stage feed-heating incorporating low-pressure evaporators for make-up supply. Sea water will be used for cooling and will be supplied from a separate pump house to be constructed on the shore. The main alternators will generate at 11,000 volts and each set will include a 1500-kW house-service alternator. A 375 kW diesel engine set will also be provided for stand-by service to the station auxiliaries. Transmission to the sub-station will be at 66,000 volts, the station output being stepped up to this voltage by an outdoor transformer and switching station adjoining the power station and controlled from an indoor control board. The main transformers will be 25,000 kVA, 11/66 kV, three-phase units. The equipment of the sub-station will include nine 6400 kVA, 66/15 kV outdoor transformers and 15 kV indoor switchgear.

New Metallurgical Research Laboratories

AN event of the week was, undoubtedly, the official opening of the new research laboratories of High Duty Alloys, Ltd., which was performed on Tuesday, April 30th, by Sir Henry Tizard, F.R.S. A large company of engineers and others interested in metallurgical research attended, and were received by Colonel W. C. Devereux, the managing director of the company. Speaking after the luncheon, Sir Henry said that it was both a pleasure and a privilege to be associated with the good work of the firm. Starting from small beginnings in 1927, it had built up a business in high duty alloys which, he said, was now a great national asset, of the utmost importance to the Royal Air Force. It would be equally important in times of peace. The laboratories, which were a credit to all who had planned and built them, were an embodiment of a policy of scientific research and scientific method pursued by the company with which was associated hard work, enthusiasm, and faith. All engaged in the work of the firm could feel that they were contributing to the safety, confidence, and morale of our fighting forces. In his reply, Colonel Devereux said that they had started their research programme with only five men, but the number had now increased to fifteen per cent. of the number of those engaged in production work. He paid tribute to the work of Mr. Robinson and to that of Mr. Prytherch, late of the N.P.L. who was in charge of the laboratory. Research had been applied, he said, not only to the scientific problems associated with manufacture, but also to matters connected with economy, administration and purchasing. In all sections of the laboratory work there was the closest collaboration between the factory and the administration, as well as with the research and production staffs of the customers of the firm.

Turbine Locomotive Experiences

By EDWARD H. LIVESAY

No. III

(*Continued from page* 391, *April 26th*)

CREWE TO LIVERPOOL

GETTING away from Crewe with the 400 ton load was even easier than it had been at Euston, as the track is level; there was no slipping, and again sand was not used. It was done with two valves open, but on the chiefly falling gradient to Weaver Junction—at which point the Liverpool line branches off from the main route to the north—one valve sufficed. I could not help noticing how simple the handling of "No. 6202" was—I really believe a fairly creditable performance at the controls would have been within my own powers, at a pinch! Weaver Junction was passed slow at 1.48 p.m., a minute ahead of time, the 1 in 100 climb to Sutton Weaver calling for three open valves. 1.57 p.m. found us passing Ditton Junction, 2 mins. early, so we slowed down, making an easy way along this somewhat hilly, curving section into Lime Street, Liverpool, which was reached at 2.15½ p.m., 2½ mins. under booked time. The average speed over the 35·5 miles from Crewe had been 46·8 m.p.h., and over the whole distance of 193·5 miles from Euston, with the stop at Crewe included, 53·9 m.p.h. The schedule was evidently generous, making no call whatever on the engine to show its real capabilities. I went with it to the shed, as I had been told this was a place very difficult of access, and so there seemed promise of a good chance to watch the engine's power of manœuvre—that "inching-gear" interested me. And so it proved; I have never seen a shed so awkward to get into and out of. Forward and backward movement must here alternate frequently, but "No. 6202" gave no trouble. Once or twice the "inching gear" had to be used, but it seemed quite simple to operate. I should like to describe the "inching-gear," but it is impossible to do so intelligibly without the aid of drawings, which I regret I have not got. I must be content to say that it is a spring-operated fitting that turns the reverse-turbine shaft about half a tooth when the teeth of the two halves of the dog-clutch—which is the coupling between the reverse-turbine and the first gear-wheel—happen to have come to rest in opposition. The partial turn of the shaft makes it possible for them to enter, and when the coupling is fully engaged, the inching gear is out of action. The reverse turbine is only used for shunting duties, so high power is not needed from it; hence the three astern nozzle-groups as opposed to six on the ahead turbine, and quadruple-reduction gearing as opposed to triple. Running back tender-first to the shed, the speed was roughly 20 m.p.h. There I left the engine, to devote the next couple of days to conning over my notes, and to allow a sprained ankle to recover its temper. It was fortunate that "No. 6202"'s riding was so good, or I should have experienced far more discomfort from this disability than I did. I can think of engines that I would have declined to tackle at all with a sprained ankle, but "No. 6202" came into a different category. I have not "got *her* on the list!"

LIVERPOOL CATHEDRAL

There does not seem, at first sight, to be much in common between a locomotive and a cathedral, yet if you consider a little, I believe the bond can be found! If there is in one the capacity to admire the beautiful, whether mechanical or architectural; to think highly of anything conceived in hope, wrought in determination, and brought to completion with all the care and skill that human hands can compass and lavish on it—does not this show them to have brotherhood? I had long wished to see Liverpool Cathedral, Sir Gilbert Scott's creation, and the afternoon return journey with "No. 6202" gave me the opportunity. So, before going to Lime Street Station, for an hour or more I literally worshipped in this glorious building, sitting still and silent, letting the beauty of it sink in, that the memory of it might remain with me. It has—I hope and think it always will. The wonder of it! At 21, when little more than a boy, to conceive and originate this! Genius: "an infinite capacity for taking pains"—what a grotesque definition! Surely it is born, not developed? As I sat there, contemplating, following those soaring pillars upward to the brooding, protecting arches, to the vaulting dimly visible far overhead; watching the slanting rays of sunlight filtering through the stained glass of the rosy windows, and touching the warm stone with caressing fingers, I had it in my heart to envy the man whose genius could give birth to such a monument. To have, so early in life, a vision, a dream of beauty; to convince others of its worth, and with one's own enthusiasm, to kindle the like in them; together with them, to translate the vision into reality, see it gradually take form, and the dream come true—surely this is an extreme of good fortune that is given to few? In youth to conceive—in manhood to create—in age to see completed—and passing on, to leave to countless others beneficence and inspiration. The embodiment in stone of an harmonious, orderly, useful life—such, to me, is Liverpool Cathedral.

How strange are the relations of Cause and Effect—how far-reaching! If Hero of Alexandria had not discovered that a jet of steam gave motion to vanes on a spindle, "No. 6202" would not have been built, I should not have visited Liverpool Cathedral, and this homily would never have been written. Q.E.D.

MORE DETAILS

Wanting to see as much as possible of the tractability of "No. 6202," I joined her at Lime Street, where she arrived from London at 2.18 p.m. The war was beginning to cast its ominous shadow over the railways, and extra train movements in and about the station kept us there for quite three-quarters of an hour, before the coaches were plucked away, and passage back to the shed was possible. I filled in the time looking round the engine, noting things I had missed on the previous occasion. An interested onlooker, hearing her measured panting, asked if "No. 6202" was fitted with the Westinghouse brake? I said: "No; that is the Worthington oil-circulating pump misleading you. It does sound very much like a Westinghouse."

There is a de-sanding device fitted, which comes into action automatically when sand is being used. Water washes off the rails behind the drivers, thus preventing interference with track-circuits. It is worked by handle "L," in the cab, Fig. 10 (*ante*). Grease-gun lubrication is used at several points, such as the brake-gear. In the cab, a steam-turret (Q, Fig. 10, *ante*) has numerous connections to a number of fittings—steam injector, ejector, pressure gauge, &c.—and its own connection to the boiler through a single stop-valve "R," so all the fittings can be shut off simultaneously. Other cab details will be touched on later.

LEAVING LIVERPOOL

The run back to the shed, tender first, over intricate metals, again brought the "inching-gear" into action once or twice; arrived there, coaling and watering were attended to, and the fire needed cleaning more thoroughly than usual, owing to somewhat inferior coal having been used on the run down from London. These matters, coupled with the lengthy detention at Lime Street, had cut things very fine, with the result that the fire had not nearly burnt through, and the steam pressure was low when "No. 6202" left to pick up the train. The coupling-up and start were made without the loss of a superfluous second; in fact, the whole operation was a whirlwind of snappy movement and strong language! We left at 5.28 p.m., three minutes late, and with 210 lb. steam; there had been no time to build up the fire and raise the pressure to the proper 250 lb. figure before pulling out. The crew consisted of Driver Eborall, Fireman Jones, and Fitter Parker; the load was 425 tons gross. There is a mile of 1 in 93 immediately outside the station, ending at Edge Hill, which was taken with four valves open, and again there was no slipping. I should imagine that it might be rather difficult to tell if a turbine engine was slipping; only the throw of the coupling-rods would give any indication. An extra stop at Edge Hill delayed us again, and we got away at 5.34 p.m., picking up speed rapidly along a level half-mile to Edge Hill Junction, which is followed by another little piece of 1 in 93 to the top of the bank at Wavertree. Once over the peak, "No. 6202" accelerated fast, reaching 60 m.p.h. on the down gradient through Mossley Hill, but a signal was "on," and Allerton, two miles further, was passed dead slow at 5.41½ p.m. At Halebank troughs, 9·5 miles from Lime Street, we were again doing 60 m.p.h. I noticed how little spray was thrown up by the scoop, which is the result of the "economiser," a fitting which is seen in the drawing of the "Coronation" class tender, in THE ENGINEER of November 10th last. The economiser is an inverted U-shaped collector, lowered into the trough simultaneously with the scoop, which it precedes. It tends to draw water away from the sides of the trough, and concentrate it in the middle. The result is that the depth of water becomes greatest in the middle, and least at the sides, and while it is in this "humped" condition it is caught by the scoop. Thus more water is picked up in a given time, with considerably less waste; in fact, there is practically none.

Ditton Junction, just beyond the troughs, is at the foot of a stiff climb, 4 miles in length, mostly 1 in 101–115, except for the crossing of Runcorn Bridge. It asked for, and got, four open valves, and the top was reached at 5.55 p.m.; the fire was not yet built up, and the heavy call on the boiler for steam brought the pressure down to 175 lb. Heavy firing under these circumstances, and an attempt to force things, only makes confusion worse confounded—a "green fire" results. Jones showed all a good fireman's skill, but he had

FIG. 12—"LOOK-AHEAD" FROM FIREMAN'S WINDOW

to make haste slowly, and at Sutton Weaver, a mile beyond the top of the bank, the needle had crept slowly back to 160 lb. It was a new experience, this; to be on an express engine in full flight, with the pressure 90 lb. below blowing off point, and still falling! The crew's concern infected me, and I began to watch the needle anxiously. The sand-gun was turned on here, and with easier running on a falling gradient from Sutton Weaver, coupled with a speed restriction to 50 m.p.h., the gauge became a little more optimistic. The speed shortly after, approaching Weaver Junction, where the main line is joined, was 60 m.p.h. Here I was on familiar metals again; I had felt a "stranger in a strange land" running over that Liverpool branch.

The "blinkers" were doing their work excellently, carrying the considerable smoke due to the building up of the fire well over the cab-roof. I wondered if, under these conditions, quickly adjustable cones in the blast-pipes might not have shown to advantage? Jones said the draught seemed very easy; he evidently wished there was some way of intensifying it a little. These "blinkers," Fig. 9 (*ante*), might give one the impression that they apparently obstruct the driver's "look-ahead," but, as a matter of fact, they do not, as Fig. 12, a snapshot taken at speed by myself through the fireman's window, proves.

Two injectors are fitted, one live-steam, and the other exhaust, the latter doing most of the boiler-feeding, the former augmenting the supply when necessary, and being utilised when the engine is standing. The injectors feed through a heater, and the steam for the exhaust-injector is taken from the ahead turbine. Top-feed is employed; it will

be noticed just in front of the dome, which is a later addition, and contains the regulator, or rather, the stop valve in this engine. Originally there was no dome, and the regulator was in the smoke-box. The outline of the engine gives clear evidence of our limited loading-gauge; the attentuated chimneys, diminutive dome, "reduced height" safety valves—there are four of these—and the whistle, placed horizontally. Incidentally, the "blinkers" point to the same thing; 18in. more chimney would probably make them unnecessary, though the exceptionally soft blast of "No. 6202" might still cause trouble, I suppose. British locomotive builders would welcome the additional 2ft. 6in. of height, and 18in. of width their American opposite numbers have to play with. It would simplify many problems.

At Hartford, where the speed was 60 m.p.h., the pressure had risen to 185 lb.; at Winsford, passed at 6.08 p.m., 11 mins. late, at 25 m.p.h., owing to the distant signal interfering, it was still going up, and I hoped that the approaching stop at Crewe, a few miles ahead, would bring it fully up to blowing off point. Through Minshull Vernon, where 4·5 miles of level going begin, we were running on three groups, and so it was, I think, right into Crewe, reached at 6·18½ p.m., 10½ mins late. The 35·5 miles from Liverpool, over a far from easy route, with one stop, sundry signal slowings and restrictions, had been covered in 50½ mins., an average speed of a little over 42 m.p.h. The low steam pressure had made things very unpleasant for Fireman Jones, who handled the situation as well as anyone could have done; he had my good wishes and sympathy throughout. It was all I could give him. I would have willingly gone into the bunker, and "trimmed" for him, but he did not need coal—he wanted more blast! Everybody in the cab supplied some, of course, but it was at the wrong end of the engine. "No. 6202" whispered—Jones wanted her to roar.

Rugby to Crewe

The 5½ min., stop at Crewe gave Whiston—who had come on again here—a chance to look round the engine; both fitters were very keenly concerned about anything that might conduce to the well-being of "No. 6202." The oil-cooler in front of the smokebox came in for attention; by raising the plate which forms the running-board in front of the smoke-box door, a better flow of air is induced to the cooling tubes, and this was done. There are two gauges in the cab, registering the temperature of the oil as it passes into and out of the cooler. There is also a steam-chest gauge to indicate whether the temperature of the steam to the turbines falls short of the 750 deg. which is the proper working figure. All these make the interest of a run greater for an observer.

I like the fire-door on the latest L.M.S.R. engines; it is a great advance on the primitive, unhandy arrangements I have noticed sometimes over here. It is divided, the two halves running on rollers, as is shown in Fig. 10 (*ante*). It is easily worked, and will remain in any position desired. When shut, it *is* shut—very useful to cut off revealing rays of light during an air-raid, I should think. (Passed by the Censor—I hope.) In America the divided fire-door is used too, but there the two sections swing on hinges, and are worked by a pneumatic treadle, which is the last word in labour-saving; I am all in favour of it. I mentioned this device to a fireman once—I only wish that his enthusiastic remarks could be given verbatim, but I fear the Editor would blue-pencil them (much to his regret, no doubt). "Ah! they don't think of us like that over here—we've got to work for our living!" That was the gist of them, severely paraphrased. But I fully sympathised with him; I have had to work for mine too, so we mingled our tears together, and agreed that it is a hard, hard world. And that cab seats were hard too—I wonder if a cushion would make them a little more grateful and comforting?

The start from Crewe was at 6.24 p.m., 12 mins. late, and was made with two valves open. The pressure had risen to 225 lb., and acceleration was good up the long 10 miles rise to Whitmore troughs; 1 in 330 at the foot, stiffening through 1 in 177, then easing off again towards the peak, which was passed at 6.38 p.m., speed 60 m.p.h. Here the sun came out, making lovely prismatic colours in the spray as water was picked up. It was a perfect autumn evening, after rain at Crewe—one of England's climatic quick-change acts. Down the 12 mile descent towards Stafford steam was largely shut off, so I felt that here "No. 6202" was going to have a real chance to get that pressure up to the proper figure; in fact, that it was her duty to do it! The speed rose to 75 m.p.h., as Norton Bridge was passed at 6.46½ p.m. Watching the indicator, and making notes of the riding, distracted my attention to such an extent that I temporarily forgot all about the pressure, and was taken unawares when, crashing over the points at Great Bridgeford, I was startled by the safety-valves suddenly popping off. At long last, 250 lb. showed on the gauge, and Jones's worries were at an end. Stafford was left behind at 6.51 p.m., the 24·5 miles from the start at Crewe, including the stiffish climb to Whitmore troughs, having been covered in 27 mins, 54·5 m.p.h. "No. 6202" was waking up. To Rugeley, 9·5 miles on, she took 8·5 mins.; 67 m.p.h. I now began to anticipate some fast travelling, but the home signal near Armitage dashed my hopes by very nearly bringing the wheels to rest, and when accelerating nicely from this delay, another signal a little farther on brought us down to 20 m.p.h. Evidently we had caught up with something ahead, and as Lichfield's four slender spires and the station were passed at 7.11 p.m.—the 5 miles from Armitage had taken 6·5 mins. as the result of these checks—the obstruction was revealed, and was seen to have been shunted out of our way, leaving the path clear for our faster passage Londonwards. But we were 18 mins. late at Lichfield, and I gave up all hope of our getting back on to schedule. The speed rose rapidly; after water had been picked up at Hademore troughs, Tamworth was passed at 75 m.p.h., and it remained high through Atherstone, 7.23 p.m., Nuneaton and Shilton, 7·32½ p.m. The average speed over the 25 miles from Lichfield had been roughly 70 m.p.h. Down the slightly falling gradient to Brinklow we were doing nearly 80, when steam had to be cut for the approach to Rugby, its compulsory 25 m.p.h. over the switch to the through line, and 35 m.p.h. past the station; time, 7.41 p.m., 17 mins. adrift.

I have a warm corner in my heart for Rugby. It meant something to me in the past, because of the Thomson-Houston works, where some of my all too short engineering days were spent. As to the future, there, on the left, rises the gaunt skeleton of the locomotive testing plant, which one hopes will emulate Vitry, and make it unnecessary for us to trespass on our French allies' courtesy when the powers of British engines are tried out on a test-bed. No doubt "No. 6202" will find her way there ultimately, to her individual benefit, and to that of locomotive progress in general.

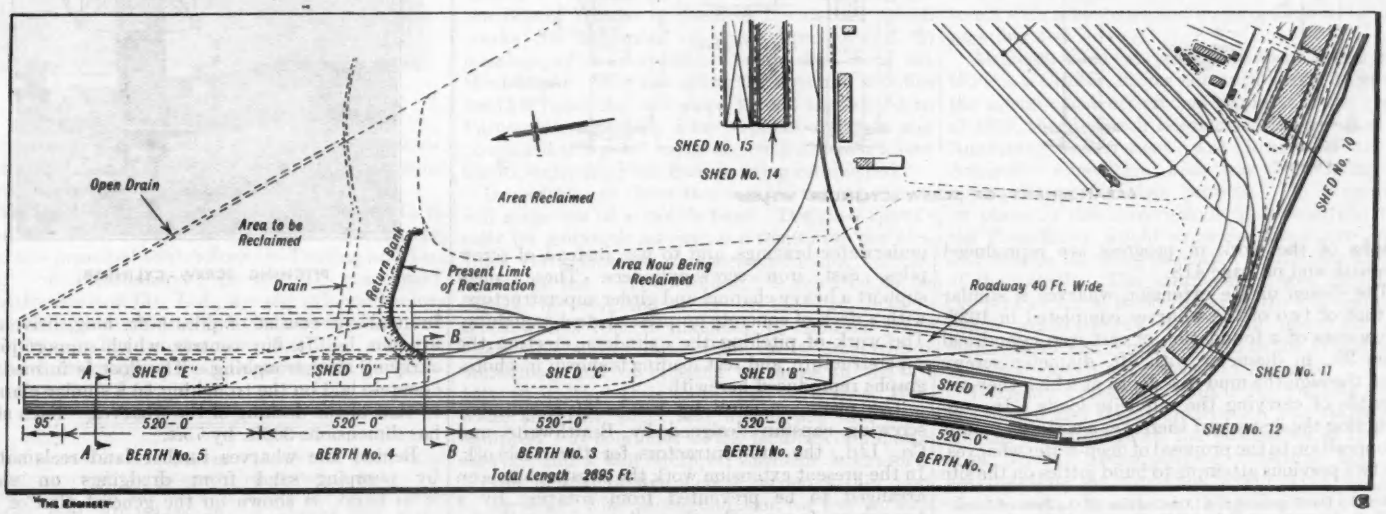
This reference to the Thomson-Houston works at Rugby reminds me that the speed-indicator of "No. 6202" was a product of this company. It is electrical, and quite different from the Hasler and Flaman devices described in previous articles. It takes the form of an A.C. generator driven from the left rear coupling-rod pin; a D.C. voltmeter scaled in m.p.h. on the dial, and the necessary rectifier. Flexible armoured cable connects the generator and speed-indicator, which is placed right in front of the driver, in an admirable position. As I have mentioned before, absolute accuracy is not always denoted by the best of speed indicators, and is not claimed—or at any rate, it ought not to be. This particular type is quite accurate enough for all practical purposes, the liability to err being found chiefly at low speeds, and even then it is not likely to exceed 5 per cent. At medium and high speeds it should be considerably less.

(To be continued)

Extensions to the Port of Beira

EARLY in 1927 a comprehensive scheme of improvement works to the port of Beira, in Portuguese East Africa, was put in hand. Beira is situated on the estuary of the Buzi and Pungwe rivers. Its geographical position makes it a natural outlet for the produce of Northern and Southern Rhodesia, and Nyasaland, and the port therefore handles much copper, tobacco, and tea. Prior to the improvement works the area of deep water available in the river in which vessels could anchor was limited to such an extent that it was sometimes necessary to remove ships from shallow to deep water in order to complete loading.

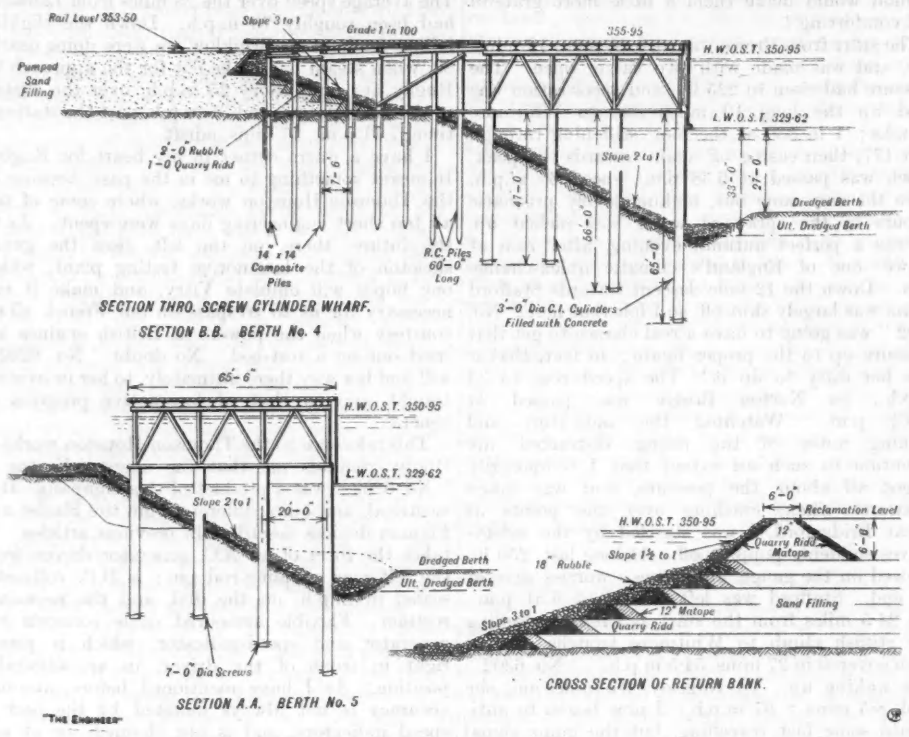
The programme undertaken in 1927 consisted of an immediate extension of the existing lighterage wharf, the construction of three deep-water berths, the dredging of the anchorage, the reclamation of land, and the equipment of the deep-water wharves with electrically-driven cranes and capstans, with a power station to supply the necessary current. The works that were carried



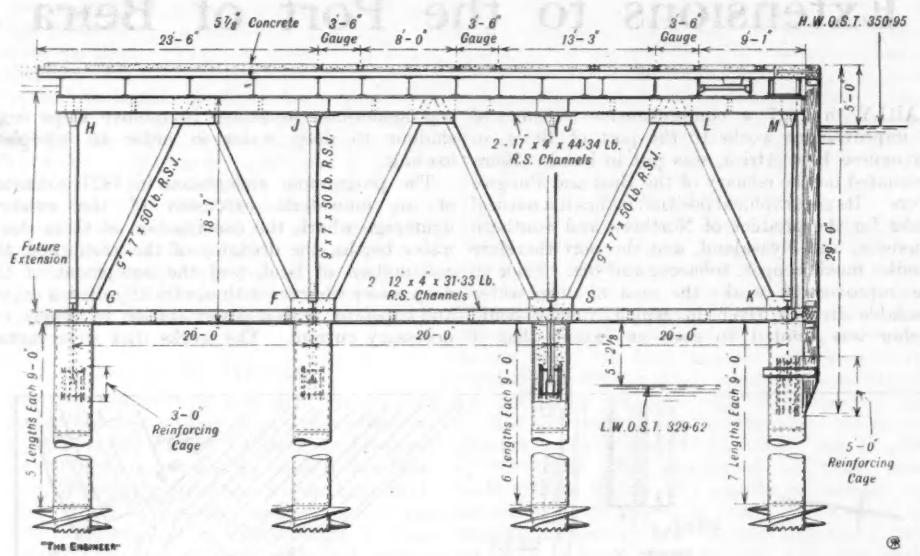
PLAN OF EXTENSIONS TO THE PORT OF BEIRA

out up to 1932 formed the subject of a paper * read before the Institution of Civil Engineers. By that date the scheme was completed with the exception of a section of the reclamation and the provision of transit sheds, which were deferred because of the depression in trade.

From 1932 onwards there was a gradual recovery in trade and the necessity arose for extensions to the completed first portion of the scheme. The Port Company therefore decided to proceed with the construction of two additional berths, each 600ft. long, forming an extension of the deep-water wharves and making a total wharfage of 2695ft., to continue the reclamation of land behind the wharves, and to erect two transit sheds, necessitating the widening of the wharves. An accompanying drawing illustrates the layout of the wharves and other drawings show typical cross sections of the return bank and berths Nos. 4 and 5, forming the extension works. Photographs of the work in progress are reproduced herewith and on page 418.



CROSS SECTIONS THROUGH WHARVES AND RETURN BANK



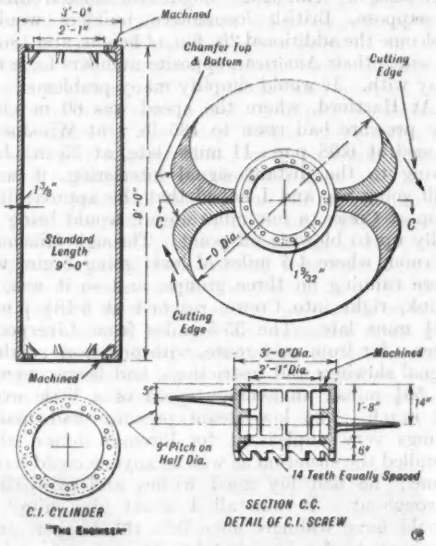
ARRANGEMENT OF SCREW-CYLINDER WHARF

The design of the extension wharves is similar to that of two of the wharves completed in 1932. It consists of a foundation of cast iron cylindrical piers 3ft. in diameter with 7ft. diameter screws sunk through the mud to a depth at which they are capable of carrying the requisite loads. In constructing the first wharf there was a certain amount of opposition to the proposal of deep-water wharves, for two previous attempts to build jetties on the site had failed. The range of tides is 21ft. 4in. at ordinary spring tides and a maximum current of 5 knots can be expected. In view of the considerable erosion of the bank that was taking place it was thought locally unwise to venture upon such a task. The design chosen, however, took account of the low bearing capacity of the mud. Mild steel screw piles, each carrying a test load of 33 tons, were driven. Where the piles were driven provision was made to protect the bank of the river from scour by a 3ft. layer of rubble stone running into a substantial toe at its lower end. Upon completion of the work it was found that, after the screwing of the piles, the river instead of scouring the bank tended to deposit silt round the piles, and therefore the fears expressed were set at rest.

As a result of the experience gained in the construction of the first deep-water wharf, it was decided to alter the original design, which required underwater bracings, and to use, instead of screw piles, cast iron screw-cylinders. These piers support a heavy channel and girder superstructure, with a deck of concrete on pressed steel troughing. The work of pitching the cylinders, erecting the superstructure, and test loading is shown in photographs reproduced herewith.

The piers are sunk by means of a cylinder-screwing capstan designed by Braithwaite and Co., Ltd., the sub-contractors for the steelwork. In the present extension work the capstan has been arranged to be prevented from rotating by a temporary framework, thus dispensing with the use of anchoring guy ropes. We are informed that the arrangement works satisfactorily and that as many as eight cylinders have been sunk in one week. When the cylinders have been sunk to the required depth, they are sealed, pumped dry, and filled with concrete. The bearing capacity is tested by a proof load of 125 tons.

Dredging of the river bank is carried out in advance of the cylinder construction, to provide the requisite slope for a protecting layer of 3ft. of rubble, placed as soon as the cylinders are set. The rubble extends beyond the front of the wharf to a distance of about 20ft. with a thickness of 6ft., so that should holes be scoured in the river bed opposite the wharf, the stone adjusts itself to a new protective slope. This method of protection has proved to be satisfactory with existing berths.



DETAILS OF SCREW-CYLINDER

The erection of two transit sheds to the rear of the wharf frontage is proceeding simultaneously with the construction of the wharf extensions. A general view of the operations at the southern end of berth No. 4 is reproduced on page 418. The foundations consist of piles 60ft. long, driven at 8ft. 6in. by 7ft. 6in. centres, which support joists carrying steel troughing. The floor is formed by concrete laid on the troughing, in a similar manner to that of the decking of the wharves. Each shed has dimensions 300ft. by 75ft.

PITCHING SCREW-CYLINDER

Behind the wharves further land reclamation by pumping sand from dredgings on shore is in hand, as shown on the general plan of the works, and a system of railway tracks is being

* "The Development and Construction of the Port of Beira," by T. C. Frampton, A.M.Inst.C.E., Proc.Inst.C.E., vol. 239.

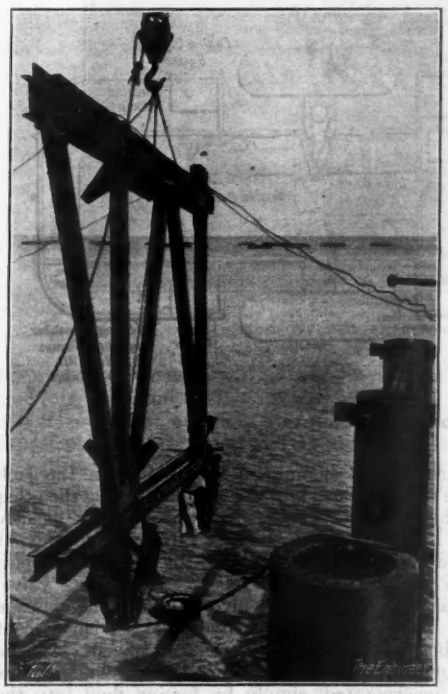
laid on the area now ready for service. In addition a roadway 40ft. wide is being built on the reclaimed land, parallel to the wharves.

For the new berths ten portal level-luffing cranes, supplied by Stothert and Pitt, Ltd., are being erected; six of them are of 3 tons capacity and four of 6 tons capacity. The total number of cranes on the deep-water wharves will then be twenty-four. Electric capstans and other gear are to be provided and the power station is being enlarged to double its previous capacity by the

TEST LOAD

installation of two oil-engined generating sets, each designed for an output of 200 kW, of Mirrlees, Bickerton, and Day manufacture.

The depth alongside the wharves is 27ft. at L.W.O.S.T., but the wharves are built to allow of this depth being increased to 33ft. when required. As regards the entrance channel to the port, it is proposed to increase the existing depths so that vessels drawing 28ft. of water can enter the port on any high tide. At present deep draught vessels are unable to enter or leave the



SETTING PART OF MAIN GIRDER

port at high water neap tides. These improvements, it is estimated, will require the dredging of about one million cubic yards of material.

The engineers for the scheme are Messrs. C. S. Meik and Halcrow, MM. Inst. C.E., of Westminster, and the principal contractors are Pauling and Co., Ltd., of Westminster; as already mentioned, Braithwaite and Co., Ltd., are the sub-contractors for the steelwork and for the screw piling and cylinders. The contractors for the entrance channel dredging are Nash Dredging and Reclamation Company, Ltd.

THE INTERNATIONAL NICKEL COMPANY IN 1937.—The annual report of the International Nickel Company for 1939, shows that the sales of nickel during the year totalled over 210,194,000 lb., of copper just under 325,000,000 lb., and of platinum metals nearly 241,000 oz.

The Antarctic "Snow Cruiser"

ONLY three men have ever reached the South Pole and explored the Antarctic regions. In 1911, the great explorers Roald Amundsen and Captain Scott competed for the honour of being the first man to set foot on the South Pole; Amundsen arrived at the Pole in December, 1911, and Scott, a month later, in January, 1912. Rear-Admiral Richard E. Byrd, of the United States Navy, became the third when, in 1929, he flew over the Pole on the occasion of his first Antarctic expedition. A second expedition was led by Admiral Byrd, which lasted from 1933 to 1935.

Much of the information available to-day on the subject of Antarctica, its resources and its natural phenomena, was obtained by the two Byrd expeditions. These expeditions were carefully organised, generously financed, and lavishly equipped, and were able to make many valuable scientific observations and survey large areas of Antarctica. Even so, 90 per cent. of this continent—larger than the United States and Mexico combined—remains unexplored.

On November 15th, 1939, another expedition, again in the command of Admiral Byrd, sailed from Boston for a three-year visit to the south polar regions. Sponsored by the United States Government and known as the expedition of the United States Antarctic Service, the expedition's objectives are to renew the attack upon the unknown regions of some 4,000,000 square miles of Antarctica; to survey such new lands as are discovered in as much detail as practicable; and to carry on scientific research in many branches of science.

The party includes approximately 55 men, 21 of whom are scientists representing almost every branch of science, and 140 dogs and 20 puppies for dog sledge service. The first stage of the journey is via the Panama canal to New Zealand, where the two ships carrying the expedition refuelled for the voyage across the Ross Sea, through the Bay of Whales to the Ross Ice Barrier, which marks the beginning of Antarctica. About 25 members of the expedition established here the West Base. After unloading the men and supplies for this base, the two ships turned northward to Valparaiso to pick up more supplies and men and proceeded to a point south of South America where the expedition's East Base is being established.

In addition to those two camps, the expedition will make use of a mobile base. Designed specifically for Antarctic service, and reminding one of a Jules Verne creation, this strange-looking vehicle, known as the "Snow Cruiser," is reported to be capable of travelling across ice fields on rubber-tyred wheels 10ft. in diameter, of climbing polar mountains, sliding down them on its steel-ribbed underfloor, and of crossing crevasses in the ice 15ft. in width. It is more than 55ft. long, 20ft. wide, and 15ft. high, and weighs 33½ tons fully equipped. It combines all the facilities of a motor caravan and a well equipped scientific laboratory. A crew of four or five men is carried within, and an aeroplane with accommodation for five persons is attached to the top of the vehicle.

COMPLETED SNOW CRUISER

The Snow Cruiser was designed and constructed by the Research Foundation of Armour Institute, in Chicago, under the direction of Dr. Thomas C. Poulter, scientific director of the Foundation and senior scientist and second-in-command of the second Byrd expedition. We are indebted to the Foundation for the particulars, photographs, and drawings reproduced in this article. The Research Foundation was established in 1936 to "render a research and experimental engineering service to industry; to conduct fundamental research for the purpose of improving our comforts of life and knowledge of science." It is affiliated with Armour Institute of Technology. Since its establishment, the Foundation, in addition to rendering its services to more than 460 companies, individuals and associations, has carried out certain fundamental researches, including some on high-speed photography, extreme high pressures and colloidal fuel.

DESIGN AND CONSTRUCTION OF THE VEHICLE

The experience of Antarctic conditions gained by Dr. Poulter led him, when he joined the Research Foundation, to visualise the vehicle which has now been constructed. The object of the design was to combine the best features of existing Antarctic transport—aeroplane, dog sledge, and tractor—and at the same time overcome their many disadvantages, such as the limited use possible of aircraft by reason of lack of bases and poor flying weather; the tractor's inability to negotiate crevassed areas; and the dog sledge's lack of space for hauling supplies and equipment. The ideal unit would be able to operate all over the continent in any kind of weather and over any kind of terrain, independent of any stationary bases. It would have storage space for a year's provisions and enough fuel to travel 5000 miles, and would provide living quarters and laboratory facilities for a crew of four to five men. Finally it would have wireless equipment for keeping in touch with main bases and an aeroplane to facilitate mapping and survey.

Although some two years were spent in designing the Snow Cruiser, it was not until late in 1939 that the actual construction was begun. In the spring of 1939, the Research Foundation learned that the American Government was interested in an Antarctic expedition and was considering an appropriation for that purpose. On presenting its plans to the Government, it was agreed that the Foundation would supervise the construction and finance the cost, estimated at 150,000 dollars, of the vehicle. The arrangement was such that the vehicle would be borrowed by the Government, which would defray its cost of operation and maintenance and return the unit to the Foundation upon the expedition's return to America.

The Snow Cruiser was built in the Pullman shops in Chicago and there construction was started on August 8th, 1939, with the fabrication of the all-steel frame. Accompanying drawings and engravings show the layout and details of construction of the unit. In order to keep the weight down and at the same time ensure the maximum strength

of construction, every structural member was joined by means of electric welds, and 100 per cent. penetration, we learn, was provided in all important joints.

When the steel skeleton was completed, it was sheathed at the bottom, sides and top in a steel skin. For the bottom 16-gauge steel sheet was welded to the I-beam frame members so that the beams protruded sufficiently to act as sledge runners. For the curved surfaces at each end 14-gauge sheet was used and 28-gauge for the skin on the sides and roof. For the structural framework, floor plates, undersheathing and wheels, a steel was required which would give maximum strength with minimum weight, high resistance to impact stress at very low temperatures, and ease of fabrication. A low carbon alloy steel, containing manganese, silicon, copper, and nickel, known as Hi-Steel, was chosen. This alloy is claimed to be 2½ times more resistant to corrosion than ordinary steel and at 50 deg. Fah. below zero to withstand impact stresses 15 times greater than ordinary steel, beside having other desirable characteristics. The welding was performed with Lincoln equipment and electrodes. As already mentioned, the total weight of the Snow Cruiser, fully equipped, is 33½ tons, and of this amount less than 13½ tons represents the structural steel.

For propulsion oil-electric machinery is used. Two oil-electric generating sets, which supply both motive and auxiliary power, are mounted in a position in front of the front wheels, and individual drives by an electric motor in each wheel hub are arranged. The generating sets each consist of a General Electric generator directly coupled to a 150 H.P. Cummins oil engine, and the traction motors are of the General Electric series-wound type, each of about 75 H.P. rating. The drive for each wheel is taken through a flexible coupling and a 50 to 1 gear reduction.

The control arrangements for the four motors in the wheels enable the driver in the navigation room to use all four motors in about thirty combinations with the two generators. Power can be directed to any one of the four wheels or to any combination of one, two, three, or four wheels. Speeds up to 30 m.p.h. are attainable, but 10 to 12 m.p.h. will probably be the cruising speed in the Antarctic. Sufficient power is provided to enable the vehicle to climb a gradient of 35 per cent. Speed control is effected by throttle control of the generators, but special manœuvring is possible by operating two or more motors in various connections. As in the operation of buses with electric drive, an increase in the generator speed resulting from increased throttle increases the voltage applied to the motors, and therefore increases their speed. The speed control of the vehicle is thus similar to that of the ordinary motor-car. But the characteristics of the generator are such that a small change in engine speed gives a large change in voltage, and therefore the oil engines operate within their economical speed ranges.

Each of the Cummins oil engines is a six-cylinder unit, operating on the four-stroke cycle. Its bore and stroke is 4⅞in. and 6in. and at 1800 r.p.m. the designed output of each is 150 B.H.P. These engines are compact and weigh about 15 lb. per B.H.P. They are fitted with a patented fuel distribution and injection system, which preheats the fuel for combustion, and, we are informed, renders starting particularly easy—a valuable point where Antarctic temperatures of minus 50 and 60 deg. Fah. or even lower are regularly experienced. Electric starter motors and batteries are provided.

The wheels, bearings, and associated mechanism of the Snow Cruiser are of much interest. Each wheel weighs three tons, and two rims for spare tyres are carried in the tail of the vehicle. Welded steel construction was adopted, and after welding and stress-relieving, each wheel structure was carefully machined to size for the bearings. The wheels measure 5ft. 6in., inside tyre diameter, and the tyres are 10ft. in diameter. Axles 1ft. 9in. in diameter are used, one for each wheel, and each wheel and axle, together with its driving motor and reduction gearing, forms a separate unit. For mounting the wheels Timken tapered roller bearings are used, stated to be the largest ever made for wheel installation. They have an inside diameter of 24in., and an outside diameter of 32in. The normal carrying capacity of each of these bearings is quoted to be 127,000 lb., although the actual maximum static load per wheel is not more than 19,000 lb. A very high factor of safety has therefore been allowed. But no spare wheel bearings are being carried. In addition to being used on the wheel spindles, Timken bearings of great excess capacity are used on all the shafts, for heavy thrust, radial and combined loads exist in holding the driving shafts in alignment and resisting shocks set up by the rough terrain over which the vehicle is to travel.

Tyres presented a difficult problem, particularly in view of the short time available before the expedition was due to sail. The problem was put before the research engineers of the Goodyear Tyre and Rubber Company. It so happened that this firm had manufactured a number of tyres 10ft. in diameter a few years ago for use with a large amphibian car designed for exploring marshlands. The mould was still in the vulcanising room, and if a tyre of that size was strong enough it could be quickly made. But to make a special mould would require months. It was decided that by constructing the new tyres in 12-ply strength, as against the four and six plies used for the amphibian car, the 33½ tons weight of the Snow Cruiser could be carried on four wheels.

Much of the surface of Antarctica is not glare ice or soft snow, but is composed of very small crystalline particles, much like sand. The tyres, which are inflated to a low pressure—from 15 lb. per square inch to 25 lb. per square inch, depending on the load and other conditions—give eight square feet of surface contact, and consequently a non-skid tread was not needed. Each tyre is 10ft. in diameter, 34½in. in width, and has a tread 1½in. thick. They weigh 750 lb. each and the inner tubes weight 250 lb. each. Gauges on the instrument board within the vehicle show the air pressure in each tyre, and the pressure can be increased at will by means of hydraulic control.

Rubber freezes and cracks at temperatures of about 75 deg. Fah. below zero, but the heat generated by the movement of the plies when the vehicle is in motion is expected to be sufficient to keep the temperature above this figure. When the vehicle is stationary the wheels will be retracted into their housings, as is explained in a later paragraph, and heat from the engine exhaust gases used to warm them before travelling begins.

Undoubtedly one of the most interesting features of the vehicle is the ingenious arrangement by means of which it will be able to cross ice crevasses. It is this requirement which makes necessary the unusual system of power, steering, and controls described below.

It might be enquired why the vehicle was designed to cross crevasses having a maximum width of 15ft. and no more. We learn that from observations in Antarctica on former expeditions it has been found that crevasses more than 15ft. wide have perpendicular walls and can be seen at some distance; that crevasses up to 15ft. wide have overhanging lips and are deceptively small in appearance; and, again, that the openings up to 15ft. wide sometimes become invisible, because they are filled with loose, windswept snow. For these reasons, the Snow Cruiser was designed to cross a maximum opening of 15ft.

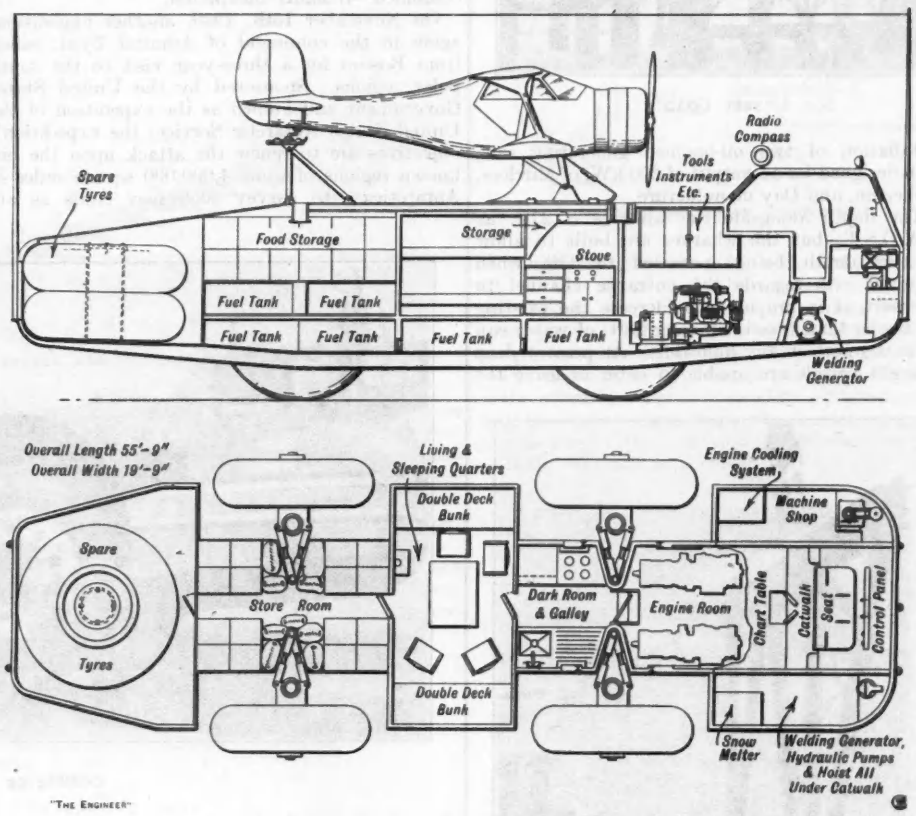
The Control System

The problem of steering, applying brakes, and elevating and lowering the vehicle with respect to its wheels occasioned much careful study. Considerable research in collaboration with Hydraulic Controls, Inc., the designers and suppliers of much of the hydraulic equipment, was done, although the equipment itself to a great extent consists of the firm's standard units.

Steering is effected by hydraulic rams, operated at 15,000 lb. pressure, controlling the deflection of all four wheels. The vehicle can be turned in a circle having a 30ft. radius by turning the front and rear pairs of wheels in an opposite sense, or the vehicle can be moved diagonally by turning both sets of wheels in the same sense. Parallelism of the wheels, both front and rear, is maintained by a device which can perhaps best be termed an hydraulic tie-bar. It consists of a steel tube, filled with fluid, connecting the hydraulic rams controlling the positioning of the wheels. If either wheel moves on its vertical axis fluid is forced through the medium of the tube from the jack on the one wheel into the jack controlling the other wheel. Hence the second wheel moves exactly in accordance with the first. In order to prevent road shocks from deflecting the wheel alignment, an hydraulic "tie-bar check," or locking valve, was designed. This valve prevents the passage of liquid through the hydraulic tie-bar except when the steering levers are moved. At the same time provision to adjust the wheel alignments is incorporated, simply by forcing fluid into the tube, or withdrawing it, so as to alter the relative position of each wheel as a unit.

Actuation of the steering rams is controlled by two steering levers, so that it is possible to move the two front wheels together by the movement of one lever, and the two rear wheels together by a second lever. However, in order to ensure accurate control of steering, two pressure valves for each set of wheels are incorporated, one valve controlling deflection to the right and the other to the left. When wheel deflection is desired, the pressure through one control valve is reduced by movement of the steering lever, causing both wheels of a pair to deflect in unison. The deflection is either rapid or slow, according to the amount of opening of the control valve, as determined by the position of the steering lever.

For various reasons hydraulic brakes were fitted to the vehicle. Since the braking system adopted operates on a closed circuit, there can be no internal



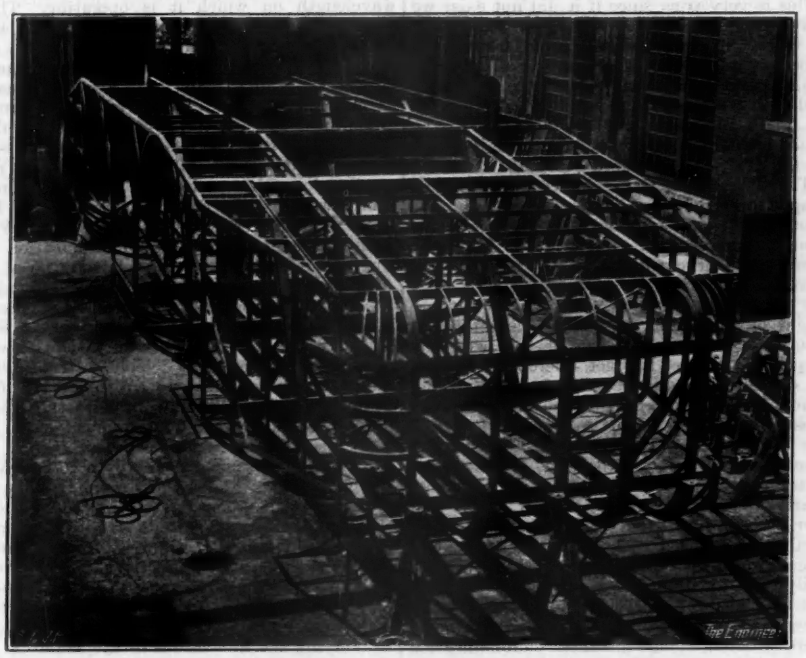
ELEVATION AND PLAN OF SNOW CRUISER

condensation of moisture, as in the case of compressed air brakes, and therefore the effect of frozen moisture is avoided. In the equipment fitted is incorporated a recently developed method of storing a large reserve supply of energy for operating the brakes, in the form of fluid pressure tanks which contain no moving or non-metallic parts which might lead to failure. Furthermore, since the fluid is non-compressible, the stored energy is transmitted from the pressure tank to the brake cylinders instantaneously, thus eliminating the lost movement and time lag associated with mechanical linkages. The brakes are operated by two separate pedals, one for the front pair of wheels and other for the rear pair.

For raising and lowering the wheels with respect to the body of the vehicle, double-acting hydraulic jacks, one on each wheel, are provided. Each jack is designed to exert a maximum effort of about 40,000 lb. For their operation reserve hydraulic power is stored in hydraulic storage batteries, charged by pumps driven by the main engines.

Various items of emergency equipment are carried. Welded chain will be used as drag chains against the wheels should the vehicle at any time need additional braking force either backward or forward. A considerable length of wire rope is also carried, so that should the vehicle become stuck in a crevasse or be confronted with a steep bank of ice or snow it will be possible to stretch the rope in front of the Cruiser a distance of 1000ft. or 1500ft., attach it to a "deadman," and thus haul it out. The rope also serves as a tow line to pull the aircraft up a 30ft. ramp to its attachments on the roof of the vehicle, and as a hoisting line to lift tyres or rims, should wheel changes be necessary, from the spare tyre compartment to the ground, whence the wheel can be swung into place by a derrick mounted on the roof. "Tru-Lay" preformed wire rope is used for these purposes; in case of an emergency break, this rope can be easily spliced or knotted—an advantage for working in extreme cold with numbed and gloved hands.

Sufficient fuel storage space is provided for nearly 2100 gallons of diesel fuel oil and nearly 850 gallons of petrol for the aircraft carried on the roof. A small supply of coal for use on any occasions when the crew are absent from the vehicle is also carried.



WELDED FRAMEWORK OF SNOW CRUISER

INTERNAL ARRANGEMENTS

In the accompanying drawings are shown the internal arrangements of the vehicle. At the front end there is a compartment measuring 12ft. by 15ft. equipped as a machine shop and scientific laboratory. The plant furnished includes a grinder, arc and acetylene welding equipment, a drill press, a lathe, and other tools.

Directly over the machine shop and laboratory is the control cabin and chart room, with dimensions 8ft. by 12ft. In the forward part of the room is the instrument panel, on which are mounted the engine controls, clocks, speedometer, pressure gauges for the four hydraulic rams which regulate the height of the wheels, a pressure gauge for the hydraulic control reservoir, indicators showing the positions of the wheels, two steering levers, four controls for raising and lowering the wheels, and a control for adjusting the toe-in of the wheels. The rear of the control room forms the chart room and is provided with radio charting, mapping, and navigation equipment.

The engine room is directly behind the machine shop. It is a compartment measuring 5ft. 3in. by 8ft., and houses the two oil-electric sets, switchboards, tools, and spare parts.

A combination galley and dark room comprises a room 8ft. by 12ft. behind the engine room. This compartment is completely equipped with an electric stove, a sink, cooking utensils, and paraphernalia for the development of photographs. Living quarters, in the form of a compartment 7ft. 6in. by 15ft., are directly behind the galley and dark room. In it are four full-length, built-in bunks, two along each side, chairs, and storage space for clothing and personal effects. Both galley and living quarters are well insulated with panel board lined with fibre glass. Both compartments have heating radiators and ceiling ventilators.

Next to the living quarters is an 8ft. by 12ft. store-room, containing some of the fuel tanks and space for stores. In the tail of the vehicle the compartment for two spare tyres measures 12ft. by 15ft., providing in addition some space for general storage.

THE SCIENTIFIC PROGRAMME

The Snow Cruiser is to take an active part in the expedition's programme of scientific investigation. It will carry much scientific equipment, including a reflection type seismic sounding recorder, a gravimeter, a dip circle for magnetic measurements, apparatus for ice studies, and instruments for both ground and aerial survey work.

The programme calls for the establishment of two meteorological observatories, including pilot balloon runs at regular intervals. There will be an exchange of data with the Argentine station on Laurie Island and with other countries planning to establish bases in the Antarctic. Data will be obtained concerning problems of the aurora, and changes in cosmic ray intensity at points of high geomagnetic latitude will be studied to determine causes of fluctuation.

Geological studies will include investigation of the structure, stratigraphy and composition of all mountains and rock exposures visited. Characteristic specimens of minerals and fossils will be collected.

Two ice laboratories will be established, one at West Base, and the other, it is hoped, by the Cruiser at the Pole. Ice studies will include thickness measurements, determination of densities of glacial ice, variations in grain size and shape with depth; and investigation of the origin of ice banding and other phenomena.

A seismograph will be erected at a stationary main base to record earth tremors. It is thought that the information so gained will be very valuable in determining the epicentres of earthquakes in the South Atlantic, South Pacific, and Indian Oceans.

Observations of declination, inclination, and total intensity of the earth's magnetic field will be made at a main base, by parties in the field and at sub-bases.

In addition biologists are to collect specimens of plant and animal life, the metabolism of members of the expedition is to be studied and a geographical programme is to be carried out.

Radio communication, of course, will play a prominent part. Consisting of standard United States naval radio equipment, all the plant is capable of sending and receiving messages. In the Snow Cruiser it consists of two transmitters, one with a power of about 200 watts, and the other of about 40 watts, both suitable for voice or code transmission; two superheterodyne single receivers, one of which is placed in the living quarters; and an emergency unit consisting of a 12-watt transmitter, for code only, and a receiver. Both the vehicle and its aircraft are equipped with direction finders, and the aeroplane is to send out a constant signal while in the air to maintain contact with its mobile base. The main bases are to be equipped with more elaborate plant and eight or nine transmitters will be available. Since the Snow Cruiser is licensed for amateur, commercial, and naval broadcasts, it is hoped to hear broadcasts directly from the vehicle in the United States and elsewhere—perhaps from the exact position of the South Pole, conditions permitting.

WHEEL AND ELEVATING GEAR

At least three aircraft are to be employed by the expedition to photograph and map Antarctica from the air. One or more aeroplanes will operate from each of the stationary bases, and one, as already mentioned, will accompany the Cruiser, making flights at 250-mile intervals. In addition to various scientific instruments, this aircraft carries an aerial mapping camera and eleven Leica miniature cameras. The cameras are so mounted that they photograph simultaneously the full 360 deg. of the earth's surface. Each flight is planned to last about four hours, and, at a cruising speed of 180 miles per hour, it will be possible to photograph a strip of territory 300 miles wide on each side of the Cruiser.

Long Distance Broadcasting*

By SIR NOEL ASHBRIDGE, B.Sc., M.I.E.E.†

THE possibilities of long distance broadcasting on a considerable scale were not generally admitted until about the year 1932. Since then millions of pounds have been spent by the several countries who have decided to establish wireless stations for this purpose.

From the engineer's point of view the problem of developing this kind of service has presented considerable difficulties owing to the large number of variable factors affecting wireless transmission over great distances. Moreover, these difficulties are increased by the fact that there is bound to be comparison on the part of the listener with local broadcasting, which may be taking place over a few miles only. The provision of a completely reliable service, having as its aim world coverage, is a fascinating problem which has not so far been

* The Royal Institute of Great Britain. Abridged Paper. January 26th, 1940.

† Controller of Engineering, B.B.C.

entirely solved. Nevertheless, so much progress has been made in recent years that one might well anticipate complete realisation in the near future, were it not for the fact that we have to deal with natural forces comparable with weather changes, which do not follow hard and fast laws. The aim which is more immediately in the mind of the engineer at the present time is rather how to reduce to a minimum the number of days in the year on which reception is ineffective. It is in fact not easy to envisage long distance transmission by wireless which will survive the severest ionospheric storms which are bound to occur from time to time. If this is to be achieved it almost seems as if we must look to some new form of wireless transmission not so far in regular use.

However, while realising the limitations of such a service, one must always bear in mind that frequently reception can be obtained from a station many thousands of miles away which is almost indistinguishable from one only a few miles away.

Let us imagine a wireless station having several transmitters and that each transmitter is adjusted to transmit on a different wavelength, and that these wavelengths are distributed throughout the wavelength spectrum. Let us suppose also that we establish a receiver 100 miles or so away which is capable of being tuned to each of these wavelengths in turn. If now all these transmitters were adjusted to radiate exactly the same amount of *wireless* energy, we should find that the longer the wave the stronger the reception. This would naturally indicate that the longer waves suffer less loss by travelling over the surface of the earth than the shorter ones, and this would in fact be a correct assumption. However, if we made careful observations lasting for some days we should find two other very interesting facts. First, that there were more interfering noises (usually called atmospherics) on the longer waves than on the shorter waves. Secondly, we should find that the longer waves remain comparatively constant during both day and night, although undergoing some variations of strength, but that waves of medium length are stronger during the night but less steady, while waves below a certain length could not be received during the night at all, or only very weakly, and that in general reception of the shorter waves depended a great deal on the time of day and were never entirely steady. Near the lower limit we might find that reception was difficult to obtain at all at such a distance.

From this we might assume that it was difficult for some wavelengths to travel through darkness and for others to travel through daylight. This, however, would be an incorrect assumption, because the mere existence or non-existence of ordinary light does not in itself materially affect the propagation of wireless waves, but obviously sunlight, or the absence of it, is having some effect. For many years these peculiarities were not understood, and owing to the wide variations of strength of reception on short waves they were not in favour with engineers who had to make practical use of wireless and were mainly concerned with reliability. On the other hand, they attracted great attention from physicists who sought to find explanations for what the engineers called *freak communication*. In those days—some 20 or more years ago—the fact that the long waves suffered less loss in travelling a considerable distance gave rise to the generally accepted idea that only such waves were suitable for inter-continental communication, in spite of the fact that their use involves a higher level of interfering noise. It was in these circumstances that the Imperial chain of very high power long-wave stations was evolved but never completed for reasons which will become clear.

Nevertheless, shortly after the last European war a number of experimenters were communicating over long distances, using very small power and mainly wavelengths below 100 m. It was found that good communication could be obtained on these short waves to places as far distant as Australia and New Zealand at times and under certain fairly definite conditions, which varied with the wavelength used. Communication was obtained which was, in fact, very much more effective than from stations using much longer waves and several hundred times the power. Gradually a satisfactory theory was evolved to account for these phenomena, although for many years it remained somewhat controversial. In detail the theory is highly complicated but the broad principle is simple.

In the first place it must be realised that radiation from an aerial does not take place only along the ground, and that some components travel into space at an angle with the surface of the earth. Again, it has now been established beyond much doubt that there exists a layer of ionised gas on the outer limits of the atmosphere which is sometimes referred to as the Heaviside-Kennelly layer, after the two well-known physicists who were responsible for a great deal of the early work on this subject. It has more recently also become known as the ionosphere, a term used to denote a rather more complicated system of layers of ionised gas than was originally associated with the term Heaviside layer. The effect of these ionised layers is to reflect or refract the waves back to earth, or at least to cause them to change their course and travel back towards the earth instead of continuing outwards into space. Thus in passing between two distance points on the earth's surface the waves need not pass along the surface of the ground, where they would be rapidly exhausted if they were of short length in accordance with the well-known propagation laws, but can proceed by an indirect route via the ionosphere, where they escape the attenuating effect of the earth's surface.

As already mentioned, it is now usually assumed that there are several layers of ionised gas which can be distinguished from each other by experimental methods. Of these there are two fairly well defined layers at different heights, which can be used to explain many, but not quite all, of the phenomena observed in communicating over long distances. All waves, except the extremely short ones, are reflected in some measure and under certain conditions. The shorter waves, in which in these days we are interested when planning very long distance communication, are in general reflected from the upper layer, while the longer waves, although normally used for direct communication along the earth's surface, are also reflected during the hours of darkness and more usually only from the lower layer. The height of the lower layer, called the "E" layer, is usually taken as about 60 miles, and the upper layer, called the "F" layer, as about 180 miles. As already mentioned there are subsidiary layers which also affect transmission. There are what are called the "D" and "F2" layers, but the precise effect of these secondary layers is a highly complex matter.

Professor Appleton once said in an article that he did not regard the lower layer as a blessing to mankind. This is very true, since if it did not exist we should avoid interference at night between transmissions on medium wavelengths used for ordinary local broadcasting where direct propagation along the ground is aimed at, at any rate so far as stations separated by relatively short distances are concerned. Again the short waves would escape the attenuation which they suffer in their passage through the "E" layer before reaching the "F" layer. The upper layer, however, certainly can be looked upon as a blessing to mankind, because it permits of world-wide communication on short waves using comparatively small power, which would be either impossible or extremely costly to effect by other means.

If the waves are reflected from the ionosphere at a height of about 180 miles, they cannot travel to a point on the opposite side of the world by one simple reflection. In fact there must be a number of reflections alternately from the ionosphere and the earth if in fact the theory of reflection is at all correct. This was one of the facts which at one time caused some scientists to try and avoid the reflection theory altogether, but it is now widely accepted and it is mentioned here more particularly in order to draw attention to the fact that over long distances reflection has to take place at several points in the geographical sense, and at these points sunlight and other conditions will not necessarily be at all similar.

It will be realised that if all wireless waves were propagated in straight lines and if no reflecting ionosphere existed, long distance communication by wireless at distances beyond 50 miles or so would be impossible. It was in fact a belief that this was the case which led some scientists to consider about 40 years ago that long distance wireless communication was fundamentally impossible. However, since all waves used for practical communication are caused by natural influences to bend round the circumference of the earth, it could be argued that it would be advantageous to use the longest wave practicable for long distance broadcasting, at any rate in certain circumstances such as during the hours of darkness. This would not, however, be advantageous, because to reach a long distance a larger number of reflections would be necessary owing to the reduced height at which reflection takes place. Secondly, the longer the wave the greater the interference due to atmospheric disturbances. There is yet another reason which will be referred to later.

If we examined the behaviour of all waves within the band which is practicable for broadcasting, we should find that for ranges of several thousands of miles waves between 11 m. and 50 m. offer the best possibilities for reliable service. Even so there are disadvantages and complications with short wave communication. In the first place it is necessary to choose a wavelength for each transmission in accordance with the following main factors:—

(*a*) the position of the transmitting and receiving points in relation to the magnetic poles;
(*b*) the time of day;
(*c*) the season of the year;
(*d*) the degree of sunspot activity on the surface of the sun.

One of the practical effects of (*a*) is that transmissions passing near either of the magnetic poles are more difficult to effect satisfactorily and are more subject to unpredictable variations. Both (*b*) and (*c*) affect the length of wave chosen but this follows fairly well defined rules. (*d*) also affects the length of wave chosen, following a law by which it is necessary to raise or lower the whole range of wavelengths selected to suit other conditions. Fortunately the results of many years' observations are now available which make it possible to predict with reasonable accuracy the optimum wavelength for a given set of conditions. It is well known that the intensity of sunspot activity follows an eleven year cycle, but there are variations of activity within this cycle which sometimes affect transmission to the extent of rendering communication almost impossible for several days at a time. Such disturbances are usually associated with magnetic storms. Variations of sunspot activity over short periods, however, may not necessarily be accompanied by magnetic storms and less severe and less prolonged reactions on communication may result. However, it will be clear that the operation of a comprehensive system of short-wave communication requires a great deal of study and vigilance on the part of the engineer responsible, which does not apply to ordinary point-to-point communication over moderate distances using long waves. Perhaps, however, the most characteristic difficulty associated with short-wave communication is the more or less continuous change of strength of reception, usually called fading. When such changes are reasonably slow and regular they can be almost entirely compensated for in the receiver; when, however, fading is deep and sudden this cannot be achieved and distortion results, particularly when the variations are not symmetrical over the whole of the frequency band transmitted. It will be remembered that a broadcast transmitter must send out a band of frequencies, and not merely the single frequency corresponding to the wavelength on which it is operating. The cause of severe variations is mainly due to the arrival of waves at the receiver which have travelled by different paths and may therefore tend to cancel each other, either wholly or in part, owing to the phase difference between them. However, there are certain advantages arising from the use of short waves other than the bare fact that transmission can be achieved economically by virtue of reflection at the ionosphere. It has been mentioned that short waves give communication over half the world's circumference with much smaller powers than are used for similar communication on long waves, but a practical example may be of interest. A powerful long wave station was erected by the Americans during the last war at Croix d'Hins, near Bordeaux, which used a power of some 500 kW to communicate across the Atlantic, whereas a short wave telegraph or telephone transmitter commonly uses only about 15 kW or 20 kW for world communication, while for broadcasting the power used does not at present usually exceed 100 kW, and more usually is in the neighbourhood of 50 kW. But there is another reason why comparatively low-power can be used for short-wave stations on land. Owing to the dimensions of the waves themselves, the radiating system can be readily constructed so as to transmit in any required direction rather than symmetrically in all directions. Thus the energy radiated is, to a large extent, concentrated in the area where reception is desired. This technique can be applied to any extent within practical limits by varying the dimensions of the radiating curtain; that is, the transmission can be confined in a beam with any desired width.

In the case of commercial point to point stations this directional effect can be used for receiving as well as transmitting, the receiving aerial being made selective with regard to direction. Moreover, the beam for transmission can be made much narrower than is feasible for broadcasting. Obviously a broadcast listener will not go to the expense of erecting an efficient receiving aerial capable of directional reception, while, of course, his receiving apparatus is less costly and more simple than that used for commercial communication. For these reasons higher power is necessary to transmit over the same path in the case of a broadcasting station as compared with a commercial one.

(*To be continued*)

WAR DAMAGE TO DRAINAGE WORKS.—The Minister of Agriculture and Fisheries recently received a deputation from the Catchment Boards' Association and the Association of Drainage Authorities in connection with war damage to drainage works. It was pointed out that the breaching of sea walls or embankments by floating mines or aerial attack might result in the flooding of large areas of land, and in the view of the two Associations the cost of repairing such damage should be borne as a national charge. The Minister assured the deputation that he fully appreciated the importance of the matter, but the Government had adopted the general policy that the question of compensation in respect of damage by enemy action was one which would have to be determined at the end of the war. He did not think that this need alarm in any way the members of the two Associations, as he was empowered to give loans to drainage authorities of the full amount of the cost of re-instatement of embankments damaged by enemy action and these loans were free of interest during the period of the war. The Minister assured the deputation that he would exercise this power promptly in all proper cases. These arrangements would prevent any cost for such repair falling on drainage authorities at least until the conclusion of the war.

Rail and Road

RAILWAY ELECTRIFICATION IN FRANCE.—It is reported that during the next five years the French National Railways are to electrify the railway lines between Brive and Montauban in the south-west and Laroche–Migerines and Lyons in the south-east, a total length of about 320 miles of line.

SAFETY DEVICE FOR RAILWAY TRACK INSPECTORS.—We have received particulars of an apparatus designed by a Soviet engineer named Pozdniak for the safeguarding of track inspectors. It comprises a portable single valve receiver carried on the inspector's belt which picks up signals from a two-valve low-power ultra short wave transmitter, installed on the locomotive, which works all the time the train is in motion. The warning signals are received on the inspector's set from about a mile away. The transmitter on the engine may also be used for radio telephone conversation between the driver and the staff of railway station towards which the train is travelling.

L.M.S. ANTI-WASTE CAMPAIGN.—With the object of meeting urgent wartime needs for commodities of all kinds, a new "salvage drive" has been initiated by Lord Stamp throughout the London, Midland, and Scottish Railway Company's system. At each of the 2400 passenger stations and 2900 goods depots, at marshalling yards, and at engineering depots receptacles are being provided for the collection of usable waste. Central dumps are being established to facilitate accumulation and sorting and to provide an easy channel for disposal. A special committee composed of representatives of every department, working under a newly appointed Salvage Officer, Mr. W. H. Vine, will co-ordinate the effort.

STREAMLINED ELECTRIC PASSENGER TRAINS.—In the United States the Chicago North Shore and Milwaukee Railroad has ordered two all-electric streamlined passenger trains for high-speed operation between Chicago and Milwaukee. Believed to be the first of their kind to be put in use in the United States, each of the two complete four-car units will weigh light approximately 160,000 lb., will be about 157ft. long, and be capable of operating with the maximum load of 133 passengers at 80 m.p.h. on 550 volts. Each unit will be provided with eight 125 H.P. 300-volt motors. Electro-pneumatic unit-switch control will provide for operation from either end of the four-car unit. The trains will be completely air-conditioned.

NEW LOCOMOTIVES ON C.N.R.—Delivery has begun of fifteen new 4–8–4 fast freight locomotives built by the Montreal Locomotive Works, Ltd., for the Canadian National Railways. Although these engines are of a similar design to a number supplied by the same builders in 1929, a number of modifications and improvements have been incorporated. The engines each have a total weight of 407,700 lb. and the tractive effort of 57,000 lb. is increased by an additional 10,000 lb. by an auxiliary engine for starting and assistance over heavy inclines. The cylinders have a bore of 25½in. by 30in. stroke, and the working pressure is 250 lb. per square inch. Although primarily intended for fast freight service the engines may also be used in heavy passenger service.

COLESHILL BY-PASS.—As a result of a deputation the Minister of Transport has reconsidered his decision to suspend the making of the Coleshill by-pass road for the time being. The Minister obtained the views of the Secretary of State for War and the Minister of Supply and as a result has decided that the scheme shall be completed on a modified basis. It is not considered that there is sufficient justification for the scheme to be carried out in its entirety and immediate needs are to be met by the completion of one carriage-way, which will be incorporated in the full scheme when finally completed. It will provide a good road for traffic and will avoid the difficulties of the present road, including the narrow bridge at the northern end of the village of Coleshill.

LIGHTING OF STATION INDICATOR BOARDS.—In order to reduce the inconvenience incurred owing to the black-out conditions at Paddington Station, the Great Western Railway Company has had the train arrival indicator board equipped with fluorescent lighting by the General Electric Company. This board, which is 30ft. wide and 16ft. high, consists of eight banks of station names headed by large numerals indicating the time that a train is due, the platform number and number of minutes late. The letters and numbers and a clock in the central panel have been treated with fluorescent powders which have been applied by a brush on an adhesive base. The board is irradiated by three 125-W "Osira" black glass ultra violet lamps in wide angle dispersive reflectors.

PRODUCER GAS VEHICLE WEIGHT CONCESSIONS.—A recent regulation announces concessions in vehicle weights in cases where coal gas and producer gas are employed. In the case of a trailer drawn by a vehicle propelled by gas, the laden weight of the trailer and the drawing vehicle may, if pneumatic tyres are fitted all round, equal, but not exceed 23 tons. Similarly, the sum of the weights of all the wheels of a vehicle must not exceed, where there are four wheels, 12¾ tons; more than four wheels, but not more than six wheels, 20 tons; more than six wheels, 23 tons, and the weight transmitted by any two wheels in line transversely may not exceed 8¾ tons. With semi-trailers, the limit is also 8¾ tons where pneumatic tyres are fitted, and the total weight of the articulated vehicle does not exceed 20 tons.

AMERICAN RAILWAY TROUBLES.—At a recent meeting of the American Society of Civil Engineers the troubles of the railroads in the United States were discussed and it was generally agreed that lack of money was the principal trouble. Mr. W. J. Wilgus considered that the railways were in a bad way technically as a result of deferred maintenance and must spend about 5000 million dollars to get back into form. Mr. M. J. Gormley maintained that the crux of most of the country's railroad troubles was government subsidisation of competing forms of transport. He said that if the government would stop building new waterways and highways and would collect tolls on existing waterways, enough traffic would return to the railways to put them into good financial form and, through lower unit costs, to permit rate reductions.

Miscellanea

MUNITIONS FACTORY EXPLOSION.—Shortly after 9 o'clock on the morning of April 20th, an explosion occurred in a mixing house in a munitions factory in the north of London. The effects were localised by the safety precautions, and although the building was destroyed the adjoining buildings were only damaged. Five men were killed and fifteen injured by the explosion.

PRIZES FOR PAPERS ON FUEL TECHNOLOGY.—The council of the Institute of Fuel has decided to award prizes each year to students for papers on subjects relating to the preparation or utilisation of fuel or allied subjects. The competition will be open to students of the Institute and to students of under 25 years of age attending any University or technical college in the United Kingdom.

NEW RUSSIAN HYDRO-ELECTRIC PLANT.—It is reported that work has begun on the construction of a 240,000 kW hydro-electric station in the Altai mountains in the U.S.S.R. It will be on the Irtysh River some six miles from the town of Ust-Kamenogorsk. This region contains a vast quantity of minerals, including nearly half the known resources of the country's lead and zinc, and it is intended that the new plant shall stimulate the development of the Soviet non-ferrous metals industry.

W. H. SCOTT MEMORIAL.—On April 27th a memorial to the late Mr. W. H. Scott, founder of Laurence, Scott and Electromotors, Ltd., was unveiled at the Gothic Works, Norwich. The memorial, which was presented by the employees and staff of the various works and branches, is a bronze plaque of the head and shoulders of Mr. W. H. Scott. It is the work of Mr. Charles Hartwell, R.A. The ceremony was attended by a number of personal friends of the late Mr. Scott and by employees, staff, and many pensioners.

THE LATE MR. E. R. PENNELL.—We regret to learn of the death of Mr. E. R. Pennell on April 18th, at the age of 41. Mr. Pennell was educated at the Judd School, Tunbridge Wells, was with the R.A.F. during the last war and received his engineering technical training at the Regent Street Polytechnic, London. After spending some time with the British-Thomson Houston Company, Rugby, Mr. Pennell joined the Hewittic Electric Company. Mr. Pennell was associated throughout with design work on rectifiers, specialising at first on automatic control gear whilst, for the past few years, he was the head of the Hewittic Company's Technical Design section.

A SUBSTITUTE FOR TUNG OIL.—A substitute for tung oil has been produced by Bakelite, Ltd., which is claimed to approximate closely to the original. It consists of a compound of linseed oil and a special Bakelite resin. Substitute varnish made from the new material is not quite as resistant to water and 1 per cent. alkali as the corresponding tung oil varnish, but is much more resistant than a varnish using unprocessed linseed oil. The storage properties of the substitute are, it is claimed, equal or superior to those of the corresponding tung oil varnish. Clear substitute varnishes have been exposed for 250 hours in a weathering machine, corresponding to about six months' exterior exposure, and none of the films is said to have shown any real sign of breakdown.

THE LATE MR. F. E. POLLARD.—The Factory Department, Home Office, has sustained a severe loss by the death of Mr. F. E. Pollard, M.B.E., H.M. Senior Engineering Inspector of Factories, who died on April 11th from injuries received in a road accident which occurred on the previous evening. Mr. Pollard joined the Department in 1909. He became an Engineering Inspector in 1926, and was appointed Senior Engineering Inspector ten years later, in which position his skill and experience were of great value in the preparation of the Safety Clauses of the Factories Act, 1937, and in his work as a member of the Mechanical Industry Committee of the British Standards Institution. He served in a technical capacity with the R.N.A.S. and R.A.F. during the years 1915–19.

COPPER BASE ALLOYS FOR DIE CASTING.—It is stated in a note in *The Machinist* that at the National Metal Congress in Chicago, Messrs. A. U. Seybolt and B. W. Gonser, metallurgists of the Battelle Memorial Institute, disclosed that on the basis of good physical properties and economy, combined with a low melting range, the best high-strength, die-casting, copper-base alloy of a large number studied by them contains 83 per cent. copper, 5 per cent. silicon, 10 per cent. zinc, 1 per cent. manganese, and 1 per cent. aluminium. It is stated that the strength and ductility of this alloy can be varied to suit specific needs by altering the proportions of manganese and aluminium. The latter makes the alloy remarkably resistant to oxidation at high temperatures. Although developed primarily for die-casting the alloy can be sand cast successfully.

TESTING OIL-WELL DRILLING MUDS.—The "Eykometer," a new device for measurement of the yield point of clay suspensions and oil-well drilling muds, is described in a report of the United States Bureau of Mines. In the examination of bentonitic clay suspensions used for oil-well drilling fluids, it is important to have comparative tests for evaluating them. An oil-well drilling mud serves several functions, many of which depend on the "gel" characteristics of the mud. Among the more important functions are:—To plaster the sides of the hole to prevent caving; to prevent the loss of the circulating fluid out of the hole by seepage; to carry sand and cuttings to the surface; and when circulation of the fluid stops, to hold the cuttings in suspension by the setting up of the gel, thereby avoiding the difficulties that result when these cuttings are allowed to fall through the fluid and pack at the bottom of the hole. To measure this "gel" property in the new instrument the mud to be examined is placed in a rubber balloon fastened to a transparent tube of special construction. The hydrostatic pressure which must be impressed to distort the balloon and cause initial motion of the mud in the tube is recorded as the "Eykometer" pressure for yield. A comparison of "Eykometer" yield pressures with Stormer gel strengths has been made and a smooth curve relation was found to result. Several determinations with the "Eykometer" to illustrate its applications have been made, including the effect of mud concentration and time of quiescent set.

Air and Water

AN AIR LINER WRECKED.—An Airways Corporation air liner which recently left Perth for Hendon crashed at Beinn Uird near Loch Lomond and its crew of three lost their lives. The machine, which had been engaged on the now discontinued Perth–Scandinavian service, was not carrying any passengers.

HYDRAULIC PUMPING MACHINERY FOR MERSEY DOCKS.—A contract has been placed with Mather and Platt, Ltd., by the Mersey Docks and Harbour Board, for the supply and erection of the machinery for a new hydraulic pumping station at one of the docks. It will consist of three sets of electrically driven multi-stage turbine pumps, each capable of delivering 300 gallons of water per minute at a pressure of 850 lb. per square inch, together with the whole of the associated plant.

A HUGE AMERICAN BOMBER.—Particulars have been published in the United States of a huge bomber which is being built by the Douglas Aircraft Company. It is known as the B 19 and has a gross weight of about 157,000 lb., its wing span being 210ft. It will be propelled by four engines with a total output of about 6000 H.P. driving three-bladed 16ft. diameter airscrews giving it a speed of 200 m.p.h. The disposable load is given as 28 tons or 40 per cent. of its loaded weight.

THE EARNINGS OF SUPER LINERS.—An open letter has been sent to members of the American Society of Naval Architects and Marine Engineers by Mr. G. C. Gaede in connection with a paper "American Superliners—Will they Pay?" read by him before the Society last year. The object of the letter, which is quoted in the *Journal of Commerce*, is to substantiate his claims that American liners similar in size and speed to the "Queen Elizabeth" and "Normandie" would be a profitable national investment. He points out that the "Queen Mary" over a three-year period carried 56,000 passengers per year, and earned about 40 per cent. on the capital investment by the operators and that she could be tied up for three or four years and still be a highly profitable investment on her 20-year life.

CANALS AND GOVERNMENT ASSISTANCE.—As a result of negotiations between the canal companies of this country and the Government, the canals have been offered financial assistance if the owners can prepare practical plans for increasing the traffic. According to the *Financial Times* the canal companies originally suggested that the Government should take control of all the main inland waterways and that a similar scheme of guaranteed revenue to that applicable to the railway companies should be made effective, and that income and expenditure on all canals should be pooled in order that compensation might be paid to those which have been particularly adversely affected by war conditions. There are about 2500 miles of canals in use in Great Britain, of which just over 900 miles are either owned or controlled by railways.

"FLAMING ONIONS."—Royal Air Force pilots, returned from flights over Germany, frequently report that they have encountered "flaming onions." These are missiles very different from the "flaming onions" of the last war. The 1914–18 type "flaming onion" was a star shell. The stars, which varied in number, were expelled from a shrapnel case and hung about in the air for a considerable time. The object was to set fire to the fabric of the old type aircraft, but the "flaming onions" of those days did very little damage. The modern version consists of light anti-aircraft tracer shells fitted with self-destroying fuses in addition to percussion fuses. If the shells hit an aircraft they explode with the usual effect. If they miss the target the self-destroying fuse is fired by the tracer. The self-destroying fuse which is fitted into the base of the shell explodes the charge so that the shell shall not injure people on the ground. As the light A.A. guns fire as many as 150 rounds a minute a stream of shells exploded by their self-destroying fuses look as though the shells are tied together and they resemble the old-type "flaming onions."

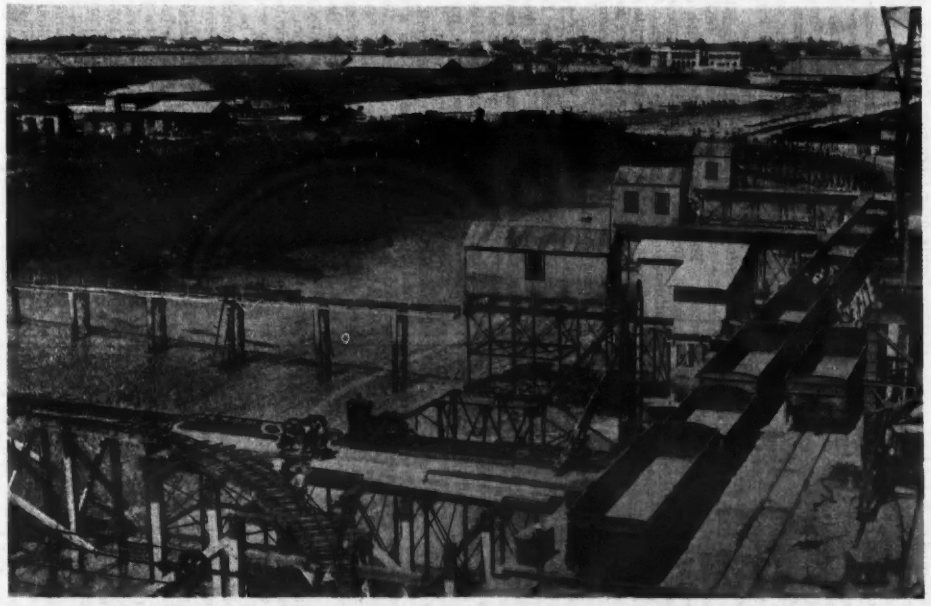
RAPID REPAIR OF PETROL TANKS.—The April number of a quarterly review issued by the International Tin Research and Development Council describes a method for the rapid temporary repairing of copper petrol tanks without the necessity for drying out all traces of petrol, which might cause fire or explosion if ordinary soldering were used. The use of tinned copper patches soldered on with Wood's metal is recommended. This alloy, which contains 50 per cent. bismuth, 27 per cent. lead, 13 per cent. tin, and 10 per cent. cadmium, has a melting point of approximately 70 deg. Cent., and it is found quite easy to use as a solder with no fire danger. Good results have been obtained by heating the soldering iron in boiling water containing about 10 per cent. lactic acid, which acts as a flux. The iron was tinned by dipping it into a pool of Wood's metal at the bottom of the hot lactic acid solution. For larger jobs it will probably be necessary to supply some additional heat to the work by preheating it with hot water. The patch may be preheated in the hot lactic acid solution; the iron should be of large size so as to retain its heat for a sufficient time.

THE PORT OF LONDON.—Lord Ritchie at a recent meeting of the board of the Port of London Authority reviewed the work and trade of the port during the past three years. He said that, with the exception of five new warehouses, all the works authorised in the Act of 1935 for the development of the Royal Victoria Dock and improvements of the Royal Albert Dock at a cost of over one and a half million pounds had been completed. Other large works involving an expenditure of well over half a million pounds had also been completed. He also gave details of a number of other substantial improvement works undertaken during the years under review. During the three years, 4,132,461 cubic yards of material were removed from the bed of the river by dredging in order to maintain and improve the channel. The quantity of mud removed from the docks during the same period totalled 3,934,121 cubic yards. Under an arrangement with the London County Council the Authority agreed to contribute to the cost of reconstruction of ten bridges involved in the Council's scheme of road improvement in the vicinity of the docks. Five of these bridges have been reconstructed and one is in the final stages of completion.

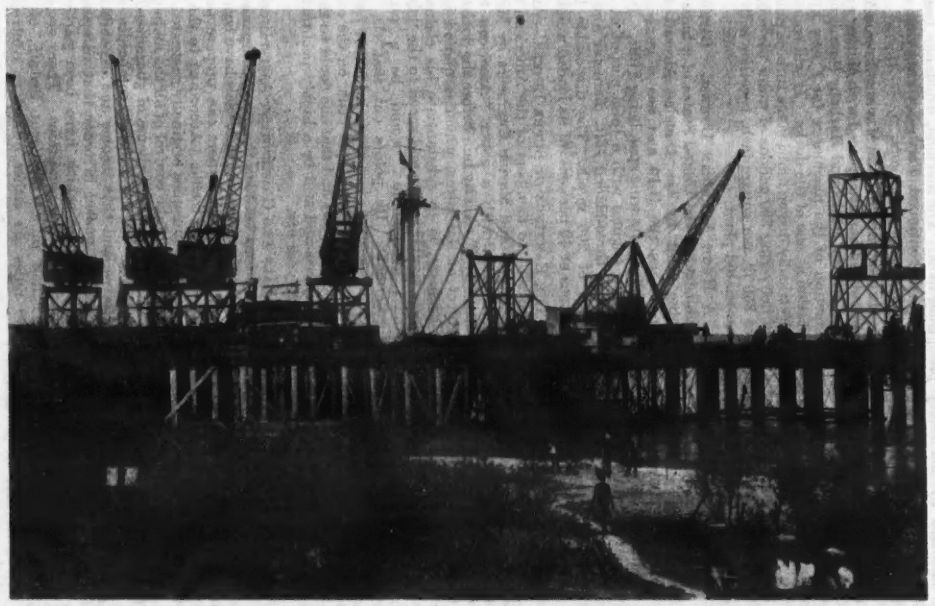
EXTENSIONS TO THE PORT OF BEIRA, PORTUGUESE EAST AFRICA

MESSRS. C. S. MEIK AND HALCROW, WESTMINSTER, ENGINEERS; PAULING AND CO., LTD., WESTMINSTER, PRINCIPAL CONTRACTORS.

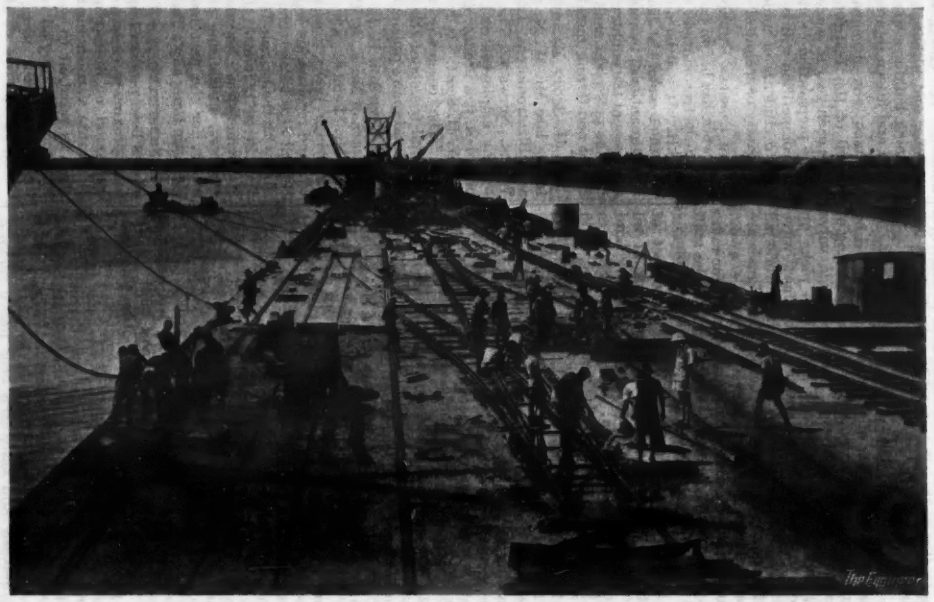
(*For description see page 411*)



SOUTH END OF BERTH NO. 4
WHARF WIDENING—BERTHS NOS. 1 AND 2



GENERAL VIEW OF OPERATIONS—BERTH NO. 4
WORK IN PROGRESS—BERTHS NOS. 4 AND 5



The Engineer

MAY 3, 1940

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WAR MEASURES

PUBLISHING AND ADVERTISING

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EDITORIAL

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GENERAL

The head office, 28, ESSEX STREET, STRAND, W.C.2, is open from Mondays to Fridays inclusive from 9-15 a.m. to 5-15 p.m., where classified advertisements may be handed in as usual and copies of the paper may be purchased. The office is not open on Saturdays.

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With a view to the conservation of paper, readers are advised, in the interests of all concerned, to place a regular order for THE ENGINEER with their newsagent or direct with the Publisher.

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*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGE OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses**, *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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PROFITS

In some distant future a regenerated world may well find some more logical standard for the measure of material values than gold and some less sordid reward than money for the encouragement of human labour, whether of the hand or of the brain. But these Utopian dreams must be left to posterity, for we have to face the facts as they stand revealed in our own times and in our own circumstances. Whether we like it, or not, our present system is based on the earning of money, which serves not only as the incentive to work but as the measure by which the results of work are in the main assessed. The workman works for wages, the professional man for fees, and the industrial and commercial community for profit. These monetary considerations are not the only incentives to effort: the real workman loves his work for its own sake; the engineer feels the urge to create something fine and useful, and these feelings are in essence the same as those which have inspired architects, painters, sculptors, and craftsmen from the days of Tubal Cain. The building up from small beginnings of a great business and watching it grow under his hand is a task to which many a man has gladly given his best and has found his reward perhaps more in the satisfaction of achievement than in the actual monetary results. Ambition plays its part:

"Fame is the spur that the clear spirit doth raise,

. . . . . .

To scorn delight, and live laborious days."

But the profit motive persists, and indeed it is well for the community and for the individual that it does, for so long as human nature remains unchanged it is the spur which stimulates effort, and it is by the effort of one individual after another that the world moves on. In normal times the earning of satisfactory profits is recognised as the main criterion of well-directed enterprise and sound management. But war produces profound changes—trades whose output is not essential for the war effort become depressed, their earnings diminish and often disappear: on the other hand, those trades whose output is required for the conduct of the war find their turnover increased and their profits proportionately augmented. These inequalities inevitably produce criticism and in the last war the unpleasing word "profiteer" was coined and applied very freely to everyone whose business and earnings improved as a result of the war by everyone who unfortunately did not share in that prosperity. The word implies taking advantage of a demand created by war conditions to insist on prices which are unfair and exorbitant, and which have no justifiable relation to costs. There were many cases of profiteering in the last war and there have been many in this, but a sharp distinction exists between the unjustifiable profits, which are made by the artificial inflation of prices, and the perfectly legitimate ones which arise from an increased output, particularly where that output is of goods essential to the conduct of the war. A business which earns no profit ends in bankruptcy sooner or later, and during its downward course it draws others with it. There are gradual dismissals of staff and reductions in wages. There is the inevitable tendency to cheese-paring economies, which reduce the quality of its output; its plant depreciates and is not maintained, and finally it falls into complete decay, leaving the ruins of its dilapidated buildings and a group of unpaid creditors and unemployed workmen as its only memorials. On the other hand, the profit-earning enterprise steadily enlarges its establishment, improves the quality of its output, provides a continually growing volume of employment, builds up its reserves against the inevitable bad times and fertilises its undertaking by the ploughing in of a substantial share of its earnings for increasing the scale of its operations and modernising its plant. Of two businesses, one making no profit and the other earning substantial returns, the latter is in every sense of greater service to the community, as well as to its proprietors, than the former. Assume that two companies (A and B) each receive from the Government an order for identical articles at identical prices; assume also that A earns a profit of 20 per cent. on the contract, while B makes no profit. The superficial critic is apt under war conditions to look upon the profit earner as a profiteer and the non-profit earner as a saint, but in practice it works out far differently, for out of the 20 per cent. profit which A has earned the Government collects income-tax and excess profits tax, in addition to sur-tax from such of the shareholders as are liable to this contribution. B not only makes no contribution to the country's revenue, but it has done something even worse for, as the cost of materials may be assumed to be identical in both instances, it is obvious that the less successful company must have employed more labour than its successful competitor in carrying out the contract, and this extra labour, in a time when labour is the main limiting factor in production, has in fact been wasted. Labour has always had a watchful eye on profit earning, and to the extent that it seeks improvement in wages as a corollary to a general average of business prosperity it is not without justification. It is apt, however, to go beyond this and to display a spirit of resentment against those businesses whose efficiency results in good earnings and consequently in substantial dividends, and in this attitude it displays a lack of full understanding. The argument apparently is that the successful business is making its profits by the undue exploitation of the labour it employs, but this argument is without substance, for the successful business makes its profit by the soundness of its policy and the efficiency of its management. It invariably pays its workpeople at least as high, and in many cases higher wages, than its competitors, while the conditions of employment are almost always more favourable. Labour has a keen, and very natural appreciation of its own profit, which in these days of almost universal payment by results is represented by constantly increasing balances over and above the standard rates of wages. These balances amount frequently in times of prosperity to 60 per cent., 80 per cent., 100 per cent., and even 120 per cent. above the normal wage rates. It is the competition for labour by the more successful employers that makes these higher balances possible, and the higher balances are earned not only by greater diligence and industry on the part of the workers, but very largely by improved methods of production coupled with the larger quantities of work of a repetition character which are available in times of pressure. If a workman can be employed almost continuously on a repetition job he acquires a far greater measure of dexterity than is possible when his job is frequently changed; he is thus able to give a greater output and his balances are proportionately increased.

There are many critics who demand that the profits of industry, particularly in war time, should be limited to a fixed, and very low, percentage, either on the cost of production, on the volume of turnover, or on the capital employed. None of these methods is free from objection, though the second one is certainly more logical than either the first or third, for, surely, the desiderata in a war industry are that its costs of production should be as low as possible, its volume of turnover as high as possible, and the capital employed as small as possible. There are cases, of course, in which some method of payment based on time, material, and establishment charges, plus a fixed rate of profit, represents the only easily available way of fixing prices—particularly where a Government Department invites a company to undertake work of a novel character with which the company is unfamiliar and in respect of the cost or value of which no established data are available. As in these instances Government money is usually provided to cover not only capital expenditure but working capital as well, it is difficult in the initial stages at, all events, to find a workable alternative until fair prices have been established by experience. This system, however, has the obvious defect that the more the job costs the greater the profit of the contractor, whereas true economy demands precisely the reverse. In normal as distinct from war conditions prices of all commodities find their true level by the laws of supply and demand, by the relative excellence of the product, and by the relative effectiveness of the commercial ability devoted to their sale; thus for each business

prices are established which represent the fair competitive value of its goods. In wartime such prices may fairly be increased but only to the extent that the factors entering into the cost of production are increased. Arbitrary increases of price, with no justification beyond the fact of abnormal demand, do in fact call for the application of the word "profiteering" with all its unpleasant implications.

The Selection of Apprentices

IF the discoveries of industrial psychology could be accepted without reserve the bottom would be knocked out of the socialistic theorem that all men are equal. Even at an early age the psychologists will pick out for you—by the help of mechanical toys and games—the boys who are likely to make good in an engineering works, and will grade the intelligence of the candidates. They will break down with a blow of statistical data the justice of equal opportunity for all, and will inform you, with but little reserve, that lads in the A class will certainly prove worthy of their salt, that those in the B class *may* develop, and that those in the C class have not the ghost of a chance and that you will waste your time trying to make silk purses out of sow's ears if you employ them. Moreover, they would leave you in little doubt that the C class had a very meagre chance of getting far in anything it undertook, whilst the B class could not be expected ever to achieve more than moderate success. In other words, nothing would be gained by offering equal opportunities to all.

Managers are being invited now, and have been for some time, to apply this system of psychological investigation to applicants for apprenticeship. That is to say to lads who have just left school. In the April issue of "Occupational Psychology," Mr. Frank Holliday presents an interim report on an investigation that has been in progress since 1938 in a large engineering works. He tells us that some 130 trade and engineering apprentices and shop boys were given intelligence and other psychological tests. Subsequently, full reports on their progress both in technical training and in the works were obtained independently from instructors and the apprentice supervisor. The reports and test results were then compared. Among other interesting facts it was found that success in a battery of specialised tests and success in engineering drawing corresponded fairly closely. So also did success in an ordinary intelligence test and success in engineering mathematics. Again, there was remarkably close agreement between the grading of trade and engineering apprentices by the specialised tests and the independent reports of the supervisor, taking into account the apprentices' records in the shops and instructional classes. Other similar facts have emerged suggesting that the tests could be relied on to indicate quickly and easily what abilities the apprentices would show in their work. There is nothing very surprising in all that. The "battery" included tests for Form Relations, Space Perception, Figure Construction, Design, and so on. One would expect a lad who ran the gauntlet of this battery to show aptitude for the elementary drawing that he would be called upon to do in a works' drawing office. So, also, we are not surprised that the boys of better intelligence succeed in the kind of engineering mathematics that would be put before them, or that those boys who showed aptitude with mechanical models had good reports from the apprentice supervisor in the shops. The results are indeed just what one would expect, and, as Mr. Holliday recognises, they do not go far enough to be conclusive. "It will," he says, "be the investigator's aim to obtain dependable shop reports on the boys studied in their investigation, and to compare these with their test results. The importance of this can hardly be over-estimated. It will, however, be a difficult one to achieve." Difficult as it may be, it is in fact the crux of the question. Unless the psychological tests can carry us beyond their immediate and expected conclusions they will be of no greater value than the less scientific methods that are familiarly employed by managers and foremen. Indeed it is very doubtful whether in any case they are any better than trying lads out at the bench or the machine. He would be a dull foreman or charge hand or apprentice supervisor who could not say in a very few days whether lads had, or had not, aptitude for any particular craft, never forgetting that any lad of reasonable intelligence who is caught young enough can be taught to do nearly anything with his hands if his interest in it can be excited or stimulated.

It is only in the biggest works, and not always in them, that apprentices are trained by special methods and selected by preliminary examinations. The traditional method is to take the sons and relations of men already in the company's service. There is a great deal to be said in its favour. Apart from the family connection with all that it implies it gives all boys an equal opportunity to prove themselves without the intervention of a scientific selective system which is certain to be adversely criticised by the unsuccessful candidate. On the whole it has worked well and its defects are more than compensated by its advantages. The principal defect is that being a "trial and error" method it takes longer than scientific selection would do, but against that loss of time, not very serious in any case, must be set the fact that the lads cannot say that they have not been given a fair chance. That some will suffer by prejudice and some advance by favouritism goes without saying. But that is common to all systems of apprenticeship—even the most advanced. Finally, the old saw "you don't know what you can do till you try" will always be true despite all psychological tests. The adaptability of mankind if it be caught young is enormous. Even in mental processes which are far more difficult than manual processes good teaching can accomplish wonders, and in manual processes for which apprentices are selected we have little doubt that given reasonable intelligence and power of application any lad could be taught to perform any operation within his psychological capacity.

Obituary

ROGER SMITH

IT is with great regret that we have to record the death of Mr. Roger Smith, formerly electrical engineer to the Great Western Railway. Following a short illness, Mr. Smith died in London on Sunday, April 28th.

Roger Thomas Smith was born at Forest Hill, London, on March 23rd, 1863, and was the son of Professor T. R. Smith, who occupied the chair of Architecture at University College, London. He was educated at Mill Hill School. His scientific training was acquired at University College and his practical experience in mechanical engineering at the works of Hathorn, Davey and Co., Ltd., of Leeds. In 1890 he went to India as the representative of Easton, Anderson, and Goolden and was given charge of the erection of pumping plant in six large cities. Subsequently, after a spell of duty as municipal and waterworks engineer at Allahabad, he returned to this country and was appointed resident engineer at the Davies Street generating station. Thereafter he spent four years at Antwerp as technical manager of the Cie. Hydro-electrique Anveroise. In 1898 he was appointed an assistant in the office of Kennedy and Jenkin, consulting engineers, and remained with that firm for seven years. During that period of his career he was closely associated with questions of electric supply and the electrification of tramways and railways—in particular with the electrification of the London County Council and the Buenos Aires tramways and of the Hammersmith and City Railway. In 1905, he was appointed electrical engineer to the Great Western Railway, a post which he continued to hold until his retirement in 1924. During his tenure of that office he carried out, among other works, the electrification of the Ealing and Shepherd's Bush Railway. In 1923–24, in conjunction with Sir Felix Pole, he was appointed to draw up a report on the Sudan Government's railways and steamers. Following his retirement from the service of the Great Western Railway he became a partner in the firm of Highfield and Roger Smith and engaged in consulting work in connection with electric supply and railway electrification in France, Belgium, and the Sudan, and for the Central England Electricity Board.

Mr. Smith was a member of the Institutions of Civil, Mechanical, and Electrical Engineers and of the Institute of Transport. He was President of the Institution of Electrical Engineers in 1919, and of the Institute of Transport in 1927. From 1929 until last year he served in the Senate of London University as representative of the engineering members of Convocation. He was of a quiet and unassuming nature and in all respects a very lovable man. There are but few electrical engineers better known in this country and his reputation was as sound upon the Continent of Europe and far overseas as it was here. Having lived to a good age, the best of his work had been done, but his memory will remain with those who were fortunate enough to count him amongst their friends.

Sixty Years Ago

As our note under this heading in last week's issue indicated much interest was being taken sixty years ago in electro-horticulture. Dr. C. W. Siemens was studying the subject scientifically. In other quarters the still mysterious powers of electricity and their influence on the growth of vegetation were engaging equal, if somewhat less scientific, attention. Almost anything on the subject could find credence. The credulous had at least this excuse for their ready acceptance of fantastic tales: electro-horticulture was no new thing and in the past, according to still extant reports, had wrought miracles. In our issue of April 30th, 1880, we find reproduced without critical comment a paragraph which appeared in the *British Chronicle* published at Kelso, Scotland, on January 12th, 1787. "Last Christmas day, and frequently since," so the paragraph said, "there was presented at table in Nenthorn House, Kelso, large asparagus, pears, kidney beans, and cauliflower, equally as good as in summer, all produced without the help of hothouse, flue, or anything of the like nature. The gardener there lately produced a grown salad from the seed, in a close room, in the space of twenty-two minutes and a half, before a numerous company, by the power of electricity." . . . Meanwhile even in scientific circles a spirit of credulity was abroad in many matters pertaining to electricity. In the issue named we reported briefly the proceedings at a recent meeting of the Society of Telegraph Engineers—now the Institution of Electrical Engineers. Professor Hughes, who had recently startled the scientific world with his investigations on the microphone, presented a paper entitled "Notes on Some Effects Produced by the Immersion of Iron and Steel Wires in Acidulated Water." He found that the mere dipping of a piece of iron wire in sulphuric acid rendered it highly brittle and gave it many of the characteristics of steel. He had also found that iron used in conjunction with zinc in a single-fluid cell made one of the most constant batteries known and was almost entirely free from the disturbing effects of polarisation. We recorded that an excited discussion followed the reading of the paper. Mr. Chandler Roberts announced in the course of it that he had extracted from iron occluded hydrogen to the extent of twenty times the volume of the iron. He argued that that fact showed an intimate connection between hydrogen and the brittleness of iron. Professors Abel, Adams, Ayrton, and Perry, and Mr. Anderson "the president of the committee formed by the Institution of Mechanical Engineers to investigate the subject," also took part in the discussion. The opinion, we said, seemed to be pretty general that we were on the right track to form some idea as to the reason for that strange alteration of iron which rendered it steel.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

MACHINE TOOL TESTS AND ALIGNMENTS

SIR,—In a letter on the above subject published in your Journal on April 19th, and signed by Mr. W. J. Morgan, Secretary of the Machine Tool Trades' Association, it is stated that ". . . the British Standards Institution did not regard it as practicable at the present time to proceed with the question of preparing any British Standard Tests and Alignments for Machine Tools. . . ."

In order to avoid any misunderstanding which might arise from this statement, may I point out that the principles of the B.S.I. do not permit its undertaking any standardisation without first obtaining the full consent to the work going forward of all parties directly interested.

It is for this reason that the preparation of British Standards for Acceptance Charts for Machine Tools is not at present being pursued.

C. LE MAISTRE,
Director.

British Standards Institution.
28, Victoria Street, London, S.W.1.
April 26th, 1940.

Scientific Instruments and Apparatus

No. VI

(*Continued from page 404, April 26th*)

AN important factor in the rapid progress made during recent times in indicating and measuring technique has been the increased use of electronic devices which enable engineers to examine and measure various phenomena with a high degree of accuracy. The method employed is to convert the quantity to be measured, or a known proportion of it, into an electrical quantity. Intensity of illumination may, for example, be calculated by causing the light to vary the electron emission in a photo-electric cell or the dimensions of small machined parts can be gauged to limits finer than those possible with any micrometer by a suitable light beam and a battery of these cells.

More recently problems in delicate measurement have arisen which call for methods outside the ordinary range of experience. Most of the usual methods of dealing with these particular problems suffered from two defects which although not serious in most cases were decidedly detrimental in certain instances. The first of these defects was attributable to the fact that most measuring instruments possess a certain amount of inertia and are therefore unsuitable for investigations of phenomena which occur very rapidly. Moreover the moving systems of such instruments have a natural frequency of their own, and resonance effects may make them useless for certain measurements of periodic phenomena. The second defect is that many methods of electrical measurement impose a definite load on the apparatus under test which mitigates against perfect accuracy and may in some cases entirely destroy the value of the investigation.

What is required in investigating high-speed phenomena is some method of generating electrical pressure exactly corresponding in frequency and instantaneous values with the quantity under investigation, while imposing negligible load on the apparatus, and in addition the provision of an indicator possessing no inertia, the movement being exactly proportional to the electrical pressure. With these requirements must be combined means for making visible or of recording the movements of the indicator. The instrument that meets these requirements is the cathode ray tube, examples of which were to have been shown in various forms at the Physical Society's Exhibition by the Mullard Wireless Service Company, Ltd. Those who have devoted their energies during recent years to developing new and improved forms of cathode ray tubes have produced apparatus which not only satisfies the requirements for which it was originally developed but have evolved tubes capable of a great number of other applications, although only a few have so far been exploited.

In its original and cruder forms, the cathode ray tube was known forty years ago. The basic facts that emerged from early experiments were that in an evacuated tube containing two electrodes with a high electrical pressure maintained between them, a stream of electrons will pass from the cathode to the anode, provided that the cathode is composed of a substance which will emit electrons under working conditions. Originally the cathode was of the cold-emitting variety, but in modern tubes hot cathodes similar to those in radio valves are employed. Although not of the same physical nature as light, the electron stream or cathode ray was found to obey many of the laws that govern the behaviour of light. Normally, cathode rays are propagated in straight lines and therefore cast electron shadows if bodies capable of absorbing the rays are placed in their path. They can also be focused into a concentrated beam or pencil and can be reflected and refracted by electrical and magnetic means, just as light can be focused, reflected and refracted by lenses, mirrors and prisms. Another important point is that if the electron stream be made to impinge upon a screen coated with certain chemical substances, those substances will radiate light at the point and instant of impact.

Neglecting the numerous steps in the evolution of the modern cathode ray tube, it will suffice to say that, as now used, it is of roughly conical shape, and is either exhausted to a high vacuum, when it is said to be a "hard" tube, or has a small quantity of inert gas introduced into it, and is then known as a "soft" tube. At the smaller end of the apparatus is the emitting cathode, with its emissive properties stimulated by raising its temperature electrically. Within the tube are also various electrodes consisting of metal plates, tubes, and discs, to which are applied electrical potentials for the purpose of accelerating the electron stream and of focusing it into a concentrated beam. Two pairs of plates, parallel to the mean path of the beam but at right angles to each other, or alternatively two pairs of electro-magnets similarly disposed, can be connected to the electrical quantities to be measured, which cause the beam to be deflected simultaneously in two mutually perpendicular directions. The electrical quantities to be observed are, of course, derived from the actual phenomena to be examined, such as the crank angle displacement of a reciprocating engine or the simple harmonic displacement of the piston in a cylinder.

At the wide end of the tube the internal surface is coated with fluorescent material which makes visible the movement of the beam for observation or photographic recording. If necessary, as in the case of television, an additional electrode in the tube can be made to "modulate" or vary the strength of the beam in accordance with the incoming impulses. All this may be elementary to many electrical engineers, but not so to others.

The more important series of engineering applications concern at present the investigations of extremely rapid changes in mechanical pressure, such as those occurring in the cylinders of high-speed internal combustion engines, and the examination of mechanical vibrations in various parts of power installations, or, in fact, in any mechanical system. In dealing with cylinder investigation it is clear that it is necessary to provide two electrical voltages, one varying with cylinder pressure, and the other corresponding to either the crank angle or piston displacement, according to whether the final trace is to be a pressure-time or pressure-volume diagram. For the pressure element a measure of success has been obtained by applying the cylinder pressure to a stiff steel diaphragm, the minute movement of which produces changes in the magnetic flux of an electro-magnetic system, thereby setting up voltages proportional to the rate of change of pressure. More recently a resistance element has been used in which the movement of the diaphragm varies the compression of a pile of discs either of carbon or of a composition producing corresponding variations in the electrical resistance of the pile.

A method of producing the deflecting impulse corresponding to the time base of the diaphragm is to arrange that a condenser be charged through a resistance in a period corresponding to the cycle under examination, the condenser being suddenly discharged at the end of the cycle by a short circuiting contact driven from the engine's crankshaft. For pressure volume diagrams, the horizontal deflection of the beam to correspond with the piston movement can be obtained in a variety of ways. A simple method is to include in the deflector circuit a suitable battery and a strip of high-resistance metal, driven from the crankshaft with a reciprocating motion between roller contacts, thus varying the resistance in circuit in accordance with the piston's movement. In some instances a specially designed dynamo driven from the engine is used to provide the horizontal deflecting impulses. An interesting series of investigations can be conducted for the observation and measurement of vibration by the use of a small condenser composed of two small plates, one of which is rigidly supported and the other connected to the vibrating member. Movement of the second plate varies the electrical capacity of the arrangement, which in turn controls the anode current of a thermionic valve and the amplified current is used for deflecting the ray.

The uses of the cathode ray tube in mechanical investigations could be multiplied, but sufficient has been said to indicate the wide field of the apparatus, particularly in connection with heat engines, hydraulic engineering, structural engineering, and in fact in any branch of industry where rapid periodic fluctuations of pressure, vibrations, and similar phenomena require investigation. Owing to the rapid progress of television development, the cathode ray tube has become an instrument of extreme precision, but it is desirable that engineers should make their requirements known to makers of cathode ray tubes, who are ready to give advice and assistance in developing suitable apparatus for the work they propose to undertake.

THE MULLARD WIRELESS SERVICE COMPANY, LTD.

The Mullard cathode ray oscillograph shown in Fig. 61 and designated GM 3156 has been specially designed for the heavy engineering industry. It is suitable for many low-frequency investigations and is built for workshop use. The apparatus comprises a gas triode time base which may be recurrent or single sweep, a high-gain amplifier of wide frequency range, and the necessary power

FIG. 61—CATHODE RAY OSCILLOGRAPH—MULLARD

supply for the amplifier, time base and cathode ray tube. The switching arrangements enable use to be made of either external or internal time base and synchronising voltage. A special fixing ring is provided over the screen for use with a camera attachment or to position a transparent scale for calibration purposes. All continuously variable controls have graduated dials to facilitate resetting the apparatus. The cathode ray tube is a high-vacuum tube with a screen diameter of approximately 4in.

To deal with the complete specification of interest to those familiar with this class of apparatus, the frequency range of the time base is from 0·25 cycle per second to 2000 cycles per second, covered in ten ranges with continuously variable control over each range. A switch position is available for single sweep deflection, the scanning speed of which is also continuously variable. The amplifier consists of two stages in

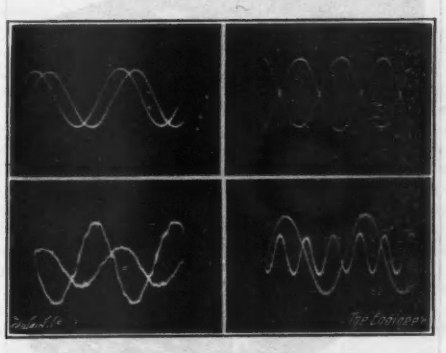


FIG. 62—DOUBLE IMAGE OSCILLOGRAMS

push-pull connection having a flat characteristic between 0·5 cycle per second and 3000 cycles per second, and nearly flat between 0·1 cycle per second and 10,000 cycles per second. The circuit switching provides direct connection with the deflector plates or where necessary the input may be *via* a stepped attenuator giving nine ranges of sensitivity directly calibrated in millivolts R.M.S. per cm. image height.

A six-way switch enables the following combinations of time base and synchronising to be used: Position (1) internal time base, internal synchronising; (2) internal time base, external synchronising; (3) internal time base, mains frequency synchronising; (4) external time base with amplifier connected to output terminals for synchronising an external time base; (5) internal time base, external synchronising from mechanical contact; and (6) single sweep time base, external synchronising from mechanical contact. Sockets enable beam modulation to be applied for time

marking. The maximum sensitivity is 1mV R.M.S. per cm. image height, and the input attenuator is directly calibrated over nine ranges from 1mV R.M.S. per cm. to 10 volts. R.M.S. per cm. According to the switching the input impedance is up to 2 megohms.

The instrument may be used on an A.C. supply working at pressures of 100 to 200 volts, the power consumption being approximately 60 watts. When the instrument is used on 100–200-volt D.C. supply an A.C. vibrator is supplied. Double image oscillograms taken with this instrument and that shown in Fig. 64 are given in Fig. 62.

The Mullard vibration pick-up detector, Fig. 63, is a moving coil inertia detector intended for use with a cathode ray oscillograph in the detection

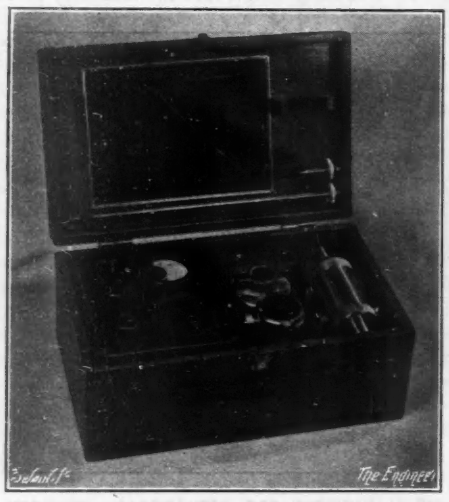


FIG. 63—DYNAMIC VIBRATION DETECTOR—MULLARD

and measurement of vibration in moving parts of relative large mass compared with the unit itself. In the casing of the pick-up is a permanent magnet with a coil and damping ring suspended in an air gap. The motion of the coil and magnet with respect to each other set up a voltage proportional to the frequency and amplitude of movement. By means of brackets the unit may be fixed to the vibrating body vertically or horizontally. Test prods are also available for exploring a vibrating surface and for use in positions difficult of access. A calibrating unit delivers a reference voltage by means of which the amplitude of vibration can be determined directly in microns. When using the calibrating unit the voltage output characteristic

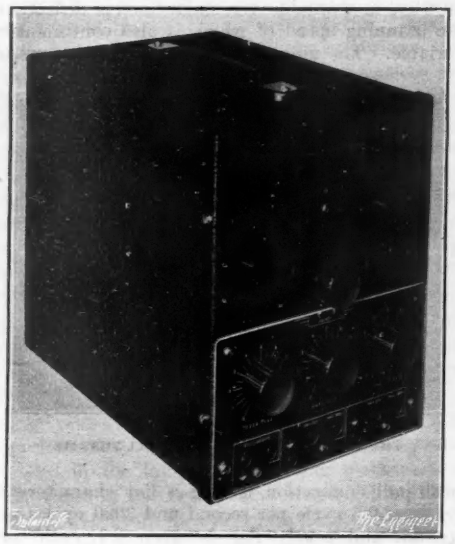


FIG. 64—ELECTRON SWITCH—MULLARD

of the pick-up unit may be chosen to be proportional to the amplitude only and independent of frequency or for a given amplitude proportional to frequency.

The complete specification for the detector is as follows:—For linear response the frequency range is between the limits 10 c.p.s. and 1000 c.p.s. The amplitude range in a horizontal direction is up to 4000 microns and in a vertical direction up to 1500 microns. When used with the oscillograph shown in Fig. 61 the smallest measurable amplitude is about 1 micron. By using the appropriate switch position on the control box, the voltage output may be (*a*) voltage proportional to velocity, and (*b*) voltage proportional to amplitude. For each pick-up unit calibration curves are supplied and a control knob on the calibrating unit is graduated directly in millivolts and microns. The sensitivity of the equipment is adjustable by means of a control on the calibrating unit.

When using the vibration pick-up in conjunction with the oscillograph, Fig. 61, a convenient means of frequency determination is afforded by the Mullard audio-oscillator, which may either be used with an electronic switch, to provide a timing wave under the vibration impulse, or by the substitution method. Alternatively the output from the audio-oscillator may be used to provide timing marks by modulation of the cathode ray beam of the tube. The complete equipment, comprising the pick-up, calibrating unit leads, mounting brackets, interchangeable test prods, and

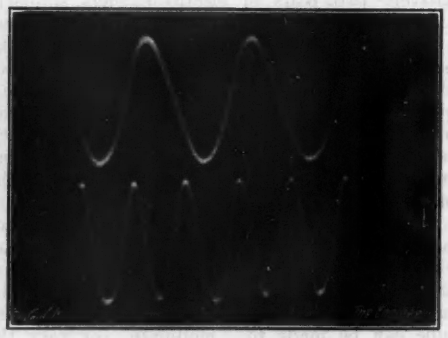


FIG. 65—TWO IMPULSES ON SEPARATE BASE LINES

calibration curves, is supplied in a portable oak case.

The Mullard electronic switch shown in Fig. 64 has been designed for the purpose of viewing two images simultaneously on one cathode ray oscillograph. The operating principle is the rapid switching in and out of two separate amplifiers by a voltage obtained from a multi-vibrator. As the switching frequency is approximately 10,000 times per second a clear reproduction of the figure under examination is ensured, even in the case of a wave form with a steep front. The two images under observation may be amplified independently of each other and be projected on to a common zero line, or if desired shifted one above the other, the original phase relation between the two impulses remaining undisturbed. In Fig. 65 are shown two impulses having a 3 : 1 ratio on separate base lines, and in Fig. 66 two impulses having 3 : 1 ratio on a common base line. It is therefore possible to make an exact study of the relationship existing between the amplitude, wave form, frequency ratio, and

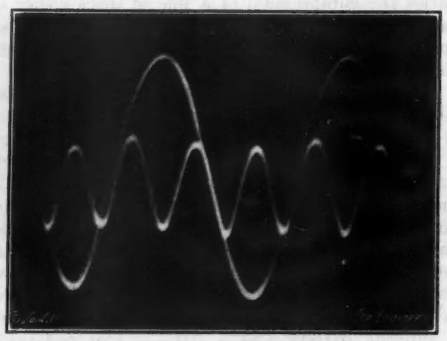


FIG. 66—TWO IMPULSES ON COMMON BASE LINE

phase shift of two electrical phenomena. As a supplement to existing measuring apparatus in the laboratory the instrument is claimed to be invaluable.

Another instrument to be introduced by the Mullard Wireless Service Company, Ltd., is a cathode ray pressure indicator for measuring pressure and vibration impulses in internal combustion engines, hydraulic systems, air compressors, oil pressure systems, &c. The apparatus has characteristics suitable for the measurement of static pressure or pressure changes up to 20,000 cycles per second, and pick-up units are to be available for pressures up to 100 atmospheres.

(To be continued)

SOUTHAMPTON DOCKS ELECTRICAL ENGINEER.—In succession to the late Mr. H. Wauchope, Mr. R. C. Miller has been appointed electrical engineer of the docks and marine department of the Southern Railway Company at Southampton. Mr. E. S. Ely has been appointed assistant electrical engineer.

The Government's Priority Organisation

ONE of the lessons learned from the war of 1914–18 was that, in the event of another war of continental magnitude it would be well to be prepared with a Government Priority Organisation which would at once marshal and direct resources of materials, men, and machines in an orderly and effective manner best calculated to serve Allied strategy. Allied military strategy, general civilian commerce, and the public purse suffered during the 1914–18 war for want of such a priority organisation carefully planned in advance. When, as is inevitable in war, the normal flow of materials was impeded and the normal demands upon labour resources and industrial capacity were thrown out of balance, adaptation to wartime conditions was by no means as swift, sure and orderly as, with planning, it might have been. Conflicting demands upon resources were not resolved promptly and in the order of precedence of need as they might have been. Belatedly and piecemeal a priority organisation was set up as the war of 1914–18 went on. This time a comprehensive organisation was planned and in existence before war broke out.

The Government Priority Organisation is extensive. At the head of it is a Cabinet Ministerial Priority Committee. This Cabinet Committee has two functions. It lays down general priority directions in accordance with Cabinet policy and it acts as the final appeal tribunal after decisions of the Priority Sub-Committee (for competing claims formulated by the Service and other Government Departments). Under the Cabinet Ministerial Committee are six Priority sub-committees. They are:—(1) Man-Power Priority Sub-Committee (which in turn has a Sub-Committee on the Schedule of Reserved Occupations); (2) Production Priority Sub-Committee; (3) Materials Priority Sub-Committee; (4) Labour Priority Sub-Committee; (5) Transport Priority Sub-Committee; (6) Works and Building Priority Sub-Committee. On these sub-committees all the interested Government Departments are represented so that the special needs of each may be advocated and envisaged.

Departments vitally interested in priority questions include the Admiralty, War Office, Air Ministry, Ministry of Supply, Ministry of Home Security and the Board of Trade representing the claims of home and export trade. It is the duty of each Department to represent to the Priority Organisation its own needs in respect of man-power, materials, productive capacity, transport, works, and buildings. It is the duty of the Priority Organisation to decide in what order and to what extent national resources in these respects shall be allocated for use. The Departments are each represented on the Priority Sub-Committee by senior officers. In addition each Department has a principal priority officer, who is an ex-officio member of all the Priority sub-committees, and an appropriate internal organisation for dealing with departmental administration of priority questions. With the exception of the Man-Power Priority Sub-Committee presided over by the Minister of Labour and National Service, the chairmen of the sub-committees are the Parliamentary Secretaries of the Ministeries most closely concerned.

There is also a department known as the Central Priority Department, which is located in the Ministry of Supply, under the charge of the Parliamentary Secretary, which is responsible for the general administration of the priority system on behalf of all Departments. No priority certificate can be issued without a notification from this Department, and it is also responsible for the allocation of manufacturing capacity between Departments, which was previously the responsibility of the Supply Board. As far as possible the Central Priority Department settles the allocation of capacity in consultation with Departments concerned and only refers cases of conflict to the appropriate Priority Sub-Committee for decision, so that appeals to the final tribunal are reduced to a minimum. The staff of the Central Priority Department consists of officers taken from the Committee of Imperial Defence and business men with first-class engineering or other specialised experience taken in from outside the Civil Service since the war started.

As a result of experience gained in the last war, it was decided that priority certificates should only be issued sparingly, if at all. Experience in the last war showed that once a system of "blanket" priority certificates was adopted the issue obtained such proportions that priority certificates became almost meaningless. In two years of the last war the Ministry of Munitions alone issued 200,000 priority certificates and at that time the Admiralty and other Government Departments were issuing them as well. It was, therefore, decided that in this war machinery should be of such a kind that no certificate could be authorised by any other body than the Central Priority Department.

A second consideration was in mind in arriving at this decision. It would have been easy enough for each of the Ministries concerned in the supply of war requirements immediately to issue priority certificates in respect of all their contracts as records of all these contracts were readily available. In respect of export trade, however, there was no such easy way. It was

realised at once that export trade is a vital element in our war effort. The Board of Trade, which is charged with looking after the interests of the export trade, naturally had no record of export contracts. A hasty issue of priority certificates by Ministries concerned with supplying the Forces might have dealt an irreparable blow to the medium through which it is hoped largely to pay for essential imports from abroad. That was avoided.

If priority certificates should become necessary during the present war, the system under which principal and subsidiary priority certificates are to be issued and the classes into which priority orders are to be divided are set out in the Priority of Work Order, 1939, No. 1080, made by the Minister of Supply under the Defence Regulations, 1939. But this general system of priority has not yet become necessary, and it is not at present intended to issue priority certificates on any substantial scale. In fact, no priority certificates at all have yet been issued. How then are essential requirements determined and how are the national resources directed to meet them in an orderly and effective manner with first things coming first, throughout the whole field of supply ?

Much information had been collected prior to the war by the Principal Supply Officer's Committee and general principles had been laid down for the allocation of production capacity and materials. For example, the Director of Industrial Planning with regard to Army supply had investigated and assessed the productive capacity that would be available for the wartime needs of the Army. His opposite numbers were similarly engaged in investigating potential capacity for the needs of the Royal Navy and those of the Royal Air Force. Reports from all these three sources were made to the Supply Board and were collated and recorded by the various Supply Committees of that Board. All those records were at once taken over by the Central Priority Department and co-ordinated in its Allocation Section. So far, when new productive capacity has been required for a particular need it has been possible to allocate fresh capacity which was discovered as a result of these pre-war surveys. These surveys have been continued since the outbreak of war and are continuing. So long as productive capacity keeps ahead of new demands there will be no need for priority certificates to be issued in respect of productive capacity.

These surveys are now being amplified by the work of the Area Boards, composed of representatives of the Admiralty, Air Ministry, Ministry of Labour and National Service, and the Ministry of Supply, and the Area Advisory Committees, which consist of representatives of the Engineering Employers' Federation and the Trades Union General Council. Up to the present, the requirements of the various Government Departments (including those of the Board of Trade for export and home trade) for certain materials have been considered by the Joint Production and Materials Committee in relation to the available supplies and an allocation of raw materials has been made to Departments. Thus the issue of Priority Certificates has not yet been rendered necessary. The allocation of the raw materials is notified by the Raw Materials Department of the Ministry of Supply to the various Controllers, who can then direct their flow to the proper sphere.

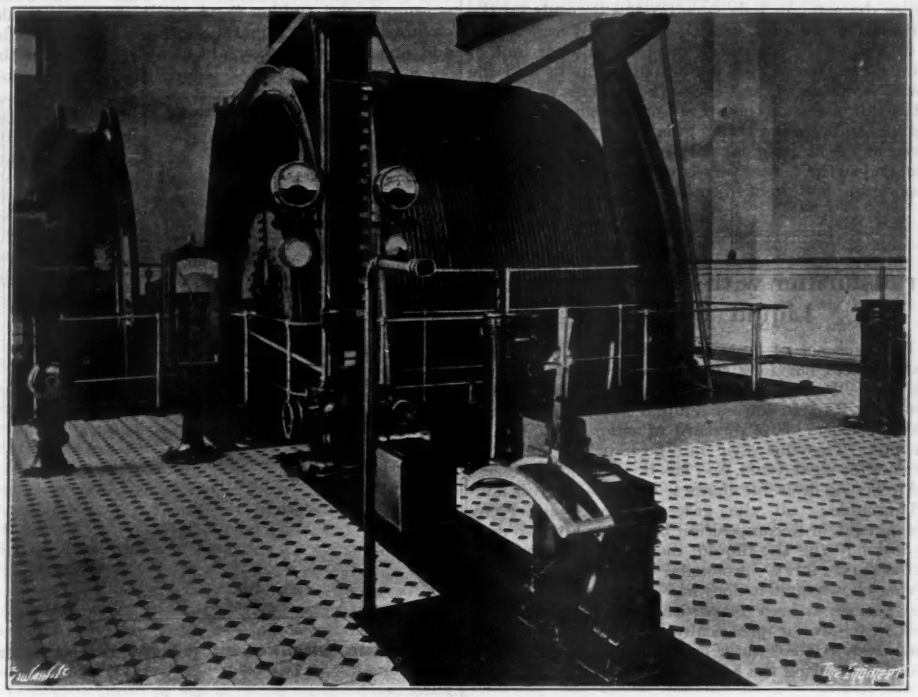
German Troop-Carrying Aircraft

ONE of the aircraft used by the Germans in the invasion of Norway is the Junkers 52, a large three-motor civil type monoplane. The type was in fairly general use for passenger and freight carrying by the Germans on their domestic and international civil air routes for some time before the war. The Ju. 52 is a low-wing monoplane with the characteristic Junkers fuselage of rectangular section, covered with corrugated alloy sheeting. The wings have a span of nearly 96ft., or 12ft. more than that of the Armstrong Whitworth "Whitley," Britain's biggest bomber at present in Service use. The normal fuel capacity would give the aircraft an operating range of about 1000 miles. In its civil transport form it had a maximum capacity for 17 passengers with luggage ; but it is likely that rather more infantrymen, with their accoutrements, could be crowded in. Alternatively, light guns and other war material could be transported in sections, stowed internally or even lashed to the external structure. Quite heavy machinery has often been carried by British flyers. A notable feat of the kind was the transport of complete gold-mining equipment into the hinterland of Papua (New Guinea) by Australian engineers. Three B.M.W. petrol radial engines of about 750 H.P. give the Ju. 52 a maximum speed of 190 m.p.h. and a cruising speed of 175 m.p.h. Unless provided with a strong escort, it would be an easy prey for any British aircraft, fighter or bomber, which fell in with it.

The transportation of large numbers of personnel by air is not new. Britain carried out the first successful large scale air movement in 1929, when over six hundred men, women, and children of a dozen nationalities, including Germans, were evacuated by Royal Air Force Vickers' "Victoria" aircraft from Kabul to India. Britain has a modern troop-carrying aircraft in the Bristol "Bombay." This bomber-transport is a two-motor, high-wing monoplane of all-metal construction. It is powerfully armed with gun turrets for its defence. Besides a crew of four, it has accommodation for 24 fully armed troops, and has a maximum range of over 2000 miles.

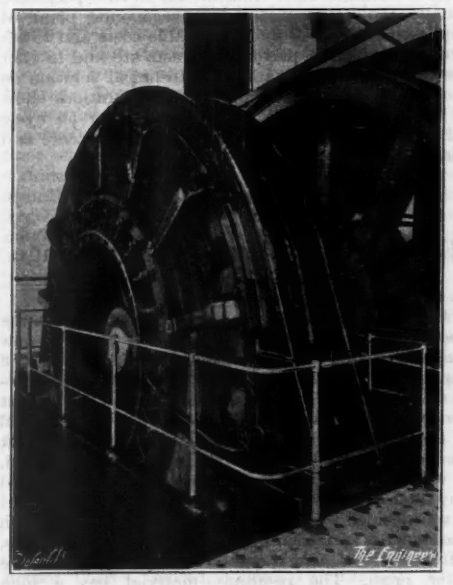
Large Mine Hoist in France

WHAT is claimed to be one of the largest and most powerful mine hoists in Europe has been installed in a French mine by the Swiss firm of Brown Boveri and Co., through its French agents, the Cie Electro-Mécanique. The hoist installation is provided with automatic safety devices which permit a stoppage of the hoist skip in case of excessive speed, and with an automatic control which moves the operating lever to a "slowing down" position, and finally to the "stop" position progressively as the skip reaches either end of its course.



LARGE MINE HOIST AT A FRENCH COLLIERY

The winding drum and the motor of the hoist are mounted on two bearings only, placed at each side of the drum, so that the rotor of the driving motor projects from one end of the common shaft as an overhang. The drum is in cast steel sections, 7·2 m. in diameter, and was assembled partly by riveting in the shop and partly by bolting on the job. Around its circumference a series of guide channels for the cable forms a spiral around the drum, except for wide, slightly projecting flanges at each end, on which the brakes of the system bear. On account of its very considerable diameter, it has been necessary to run this drum partly in a pit, the bearings being only about 2ft. above the floor level.



955 H.P. HOIST MOTOR

Brakes for the drum take the form of heavy curved steel beams, which press against the flanges of the drum. A lever system on these beams is operated hydraulically and is designed to permit a very considerable pressure to be exerted by the brakes. In order that the brake pressures may not be taken up by the shaft, the brake shoes are paired, one at each side of the shaft, making four brake shoes in all for the drum. Each pair of opposite shoes presses against the drum along a line running through both shoes of the pair so that no strain on the shaft is created.

The motor is a D.C. machine of 955 H.P. rated power, but capable of overload for short times up to four times its normal power. It has a rotor diameter of 4·1 m. The stator which is built around this rotor is in a cast steel frame which is supported on the edge of the pit in which the motor is partly sunk. The motor speed is only 22 r.p.m. Feed for the motor is provided by a Leonard converter group of 780 kW capacity operating at 1000 r.p.m. The motor of this group is of the synchronous type, and this feed installation is installed in a separate room.

Connected to the drum by means of a cable control is a depth indicator of the Brown Boveri cam type. It permits the operator not only to see at exactly what depth the skip is, by means of an indicator moving in front of a graduated scale, but also permits, by means of the cams, an automatic return of the control lever to its zero point by progressive stages. Control of the whole system is effected by means of a single lever, installed so that the operator can see the whole installation. To raise the hoist skip he has only to pull the operating lever back, and release it. In doing so, a mechanical control running to the starting resistances on the floor below starts up the motor in the desired direction. As the skip nears the end of its course, the cams on the depth indicator automatically move the lever back, by distant controls, until it reaches its zero point, at which point the brakes on the drum are automatically set.

As a safety precaution, safety brakes are provided on the hoist skip which stop the skip rapidly but progressively in case the lifting cable should break. The skip operated by this installation has a weight empty of 13·7 tons and a capacity of 13 tons. It is capable of lifting up to 211 tons per hour from the bottom of the mine, and moves up under full load at a speed of 8·3 m. per second.

Fuel Injection in Oil Engines

ON Friday evening, April 26th, an extra general meeting of the Institution of Mechanical Engineers was held at which a paper entitled "Fuel Injection in Oil Engines in Relation to Combustion" was presented by Mr. G. W. A. Green, B.Sc., M.I. Mech. E. The meeting was arranged by the Internal Combustion Engine Group. The following is an abstract of the paper.

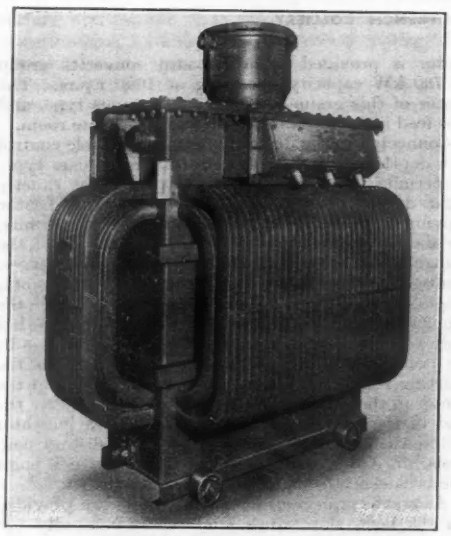
The object of the paper, which deals with the jerk pump injection system, is to show the relationship between the design of fuel injection equipment and the design of the engine on which it is used. First the nozzle is considered as an orifice, in its relation to the combustion chamber, and an account is given of the features of hole type and pintle type

nozzles. The action of the differential needle valve is then discussed, and particular reference is made to the design features necessary to ensure quick action of the valve, with good "chattering." The author then considers the design of "restricting" or "delay" type nozzles, and a description is given of the delivery valve of the pump. The need for "unloading" of the delivery pipe is discussed, together with various types of delivery valve and their action. The delivery pipe itself is treated with reference to (*a*) determination of size of pipe; (*b*) pipe surges and their effects; (*c*) methods of dealing with surges. In addition the action of a pump plunger and barrel of the ported type is considered in relation to its effect on pump output at varying speeds, also the combined effect of pump plunger and delivery valve.

The author sets out the points to be considered in the selection of fuel injection equipment for a given engine. Basing his analysis on existing designs, he puts forward a classification of combustion chambers from the viewpoint of fuel injection. He shows that orifice diameter in hole type nozzles depends on the penetration required, and that the total orifice area is dependent on the piston displacement per unit of time. The selection of a suitable pump to feed the nozzle is discussed, and the author arrives at specific ratios for assessing pump action in relation to the engine and the nozzle. Finally, consideration is given to the limiting capacity of an atomiser of given size, and to the release pressure in an atomiser and the maximum pressure of injection.

Transformer with Non-Inflammable Liquid Dielectric

THE presence of large quantities of mineral oil in transformers has long been known to constitute a fire risk. It has led the British Thomson-Houston Company, Ltd. to employ a liquid called "Permitol," which consists of a mixture of chlorinated hydrocarbons. This dielectric has been in use in transformers for eight years, and has been found to possess the following desirable characteristics:—(*a*) It is non-inflammable; all the gases involved either by evaporation or decomposition by an arc are also non-explosive; (*b*) the liquid dielectric is chemically stable and inert, prolonged commercial service having shown that it does not sludge or acidify over long periods at high temperature even up to 150deg. Cent.; (*c*) being practically non-hygroscopic and much heavier than water, in the remote event of any moisture entering the hermetically sealed transformer



1000 kVA TRANSFORMER

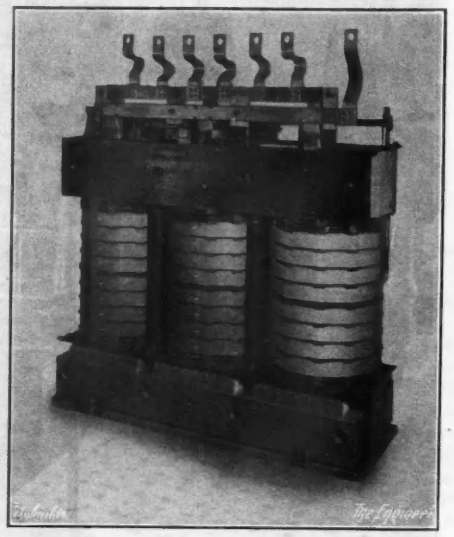
it will float on the surface of the liquid, instead of settling at the bottom; (*d*) the electric strength is as high as that of mineral oil, whilst the viscosity and cold setting point are lower than corresponding values of that oil; (*e*) the specific inductive capacity is nearly the same as that of the solid insulations used in transformers and there is consequently a better distribution of dielectric stress than with mineral oil.

Transformers with "Permitol" liquid dielectric are designed to comply with B.S.S. 171/1936 and other relevant British Standard Specifications. In construction they differ from oil-filled transformers on account of the action of the "Permitol" liquid dielectric on some materials normally used in the construction of oil-filled transformers and the need to minimise the volume of the dielectric because of its relatively high cost. For these and other reasons "Permitol" cannot be used in transformers designed for oil-filling.

The construction of the core and coils is similar to that of oil-immersed units, except that all the materials and treatments used are specially selected to be unaffected by "Permitol" and the design is made as compact as possible to reduce the volume of the dielectric. To avoid having to break hermetically sealed joints to change tappings, "off" circuit tapping switches with handles for external operation are fitted as standard.

Apart from the fact that tubes of special section are used to reduce the dielectric content and that the sampling valve is situated at the top, the tanks are of normal construction. The usual fittings are provided, including a liquid level gauge drain valve, earthing terminals, and rollers. As the transformers are hermetically sealed conservators and breathers are not required.

For the relief of internal pressure under fault conditions, a relief diaphragm is designed to operate at a higher pressure than that encountered in normal service. Where possible a relief pipe connecting the vent to the outer atmosphere should be provided, but where this is impracticable a gas absorber is bolted over the diaphragm to absorb any gases caused by an internal fault. Although these gases are non-poisonous and unlike those evolved under similar circumstances by mineral oil are non-inflammable and non-explosive, they are nevertheless unsuitable



CORE AND WINDINGS OF 1000 kVA TRANSFORMER

for human respiration and should not be allowed to accumulate in an enclosed space.

As the cost of transformers with "Permitol" liquid dielectric is relatively high, their application is limited to positions where transformer oil would constitute a serious danger in the event of fire. Their use should be confined to the basement of large buildings, boiler houses, electric furnaces, control points in factories, mines and under tunnels, and vaults under streets, &c. In such cases it is often impossible or very expensive and inconvenient to instal oil-filled units with adequate safeguards against fire. To situate such transformers in safe positions, usually remote from the most economic point of application, involves increased cable costs and losses and "Permitol" liquid transformers are said to offer the most economical and best technical solution to the problem. The accompanying illustrations show a 1000 kVA, 10,750/410 volt three-phase 50 cycle "Permitol" transformer complete and the core and windings.

Electrical Equipment for Sewage Disposal Plant

BECAUSE of the expanding industries and increasing population in its area, the Borough of Luton is now building a new sewage disposal works which will supersede the existing works and will include modern plant and processes throughout. The biggest problem of a sewage works is the efficient disposal of the sludge after its separation from the liquid that can be purified. Unless this sludge is specially treated, it will choke any land on which it is deposited and any filter in which it is handled. For the Luton plant it was decided to adopt the Porteous process in which the sludge is treated at high temperature and pressure. After this treatment it can be readily de-watered in a filter press. The resultant material has a high calorific value—something of the order of 9000 B.Th.U. in a completely dry state—and is used as boiler fuel.

From the filter press the caked material falls on to a conveyor leading to a cake-breaking machine from which a belt conveyor takes it to the boiler house. It is then picked up by an elevator, fed to a scraper conveyor, and distributed to the bunkers. These bunkers have a second compartment for coal, which can be used if there is a shortage of press cake fuel. The fuel is fed to the mechanical stokers of tri-drum water tube boilers manufactured by International Combustion, Ltd., steam being generated at 180 lb. per square inch and superheated to 550 deg. Fah. The boilers are fitted with special air heaters feeding hot air to the furnaces which help to dry the press cake immediately before combustion.

In the engine-room there are three Browett-Lindley engines coupled to British Thomson-Houston 100 kW alternators running at 600 r.p.m. and generating at 400 volts, three-phase, 50 cycles. The main switchboard in this engine room is of B.T.H. manufacture, and comprises three alternator panels, a thyratron voltage regulator panel, a blank panel, and three power and lighting panels. All the plant in the engine-room is being supplied by W. K. Porteous, Ltd., and includes four large low-pressure air compressors manufactured by Activated Sludge, Ltd., each driven by a B.T.H. 50/15·8 H.P. variable-speed A.C. commutator motor with hand-operated brushgear for regulating the speed between 1425 and 450 r.p.m. The main sludge pumps are driven by two B.T.H. 20/10 H.P. variable speed A.C. commutator motors with a speed range of 1400/700 r.p.m. Induced draught and forced draught fans, stokers, pumps, conveyors, cake breakers, and other machinery are all driven by B.T.H. squirrel-cage induction motors with direct-on starters.

Protecting Blueprints

BLUEPRINTS which are in continual use in workshops do not as a general rule last for very long owing to the grease, dirt, oil, &c., which is deposited upon them by continual handling and the splashes of liquids such as coolants and oils they receive from the machines. Attempts to read these soiled drawings involve much waste of time and not infrequently lead to errors as a result of the dimensions being partially obscured. In order to obviate these drawbacks and at the same time increase the effective life of blueprints a new protective compound has been introduced by Firminger and Gregory, 1, Lonsdale Road, Kilburn, N.W.6. This compound, known as "Fex," is applied to the blueprints with a brush and allowed to dry before they are sent out into the workshop. It imparts on to them a glazed protective coating which is not only oil, water and grease resisting, but also tends to sharpen the lines. If the prints are left unmounted the compound is applied to both sides of the paper. It can also be used as an adhesive for mounting the prints on boards or for the sticking of modifications on to the original blueprints. We have tested a blueprint treated with "Fex" with oil, hot water, petrol and grease, in each case, and providing the surface was not rubbed too vigorously the print was unharmed and its coating not visibly affected. The treated blueprints can be rolled for storage, but we have found that when they are folded there is a tendency for the protective coating to crack along the seams and with any subsequent rough handling to crumble off with a surface of the paper.

American Highway Developments

CONSTRUCTION of new roads in a predetermined highway system and improvement of many older roads by widening, paving, and reduction of curves and gradients so as to conform to modern conditions of traffic continue to be leading activities in the United States. And with the present disturbed condition of international affairs the question has arisen as to the military value of the highway system. During 1939, nearly 30,500 miles of new roads were built, of which 2860 had hard paving (mainly concrete), and 16,000 miles had various types of bituminous surfacing. The total cost approximated £150-million, of which about 70 per cent. was for construction, and the remainder for maintenance. For the 1940 programme, the budgets of the national and state governments aggregate £160-million, of which £120-million will be for new construction. In general, construction and maintenance represent 66 per cent., and 34 per cent. of the total, the latter also including the purchase of mechanical equipment for maintenance work. While express or high-speed roads are developing rapidly on main routes, their traffic is hampered by difficulties in passing into or through cities, the by-pass system not providing for all fast travel. A present problem lies in the difficulties of procuring and paying for the land necessary for high-speed city thoroughfares. Another problem lies in the cost of eliminating level crossings of heavy-traffic intersecting roads. Footpaths for pedestrians are provided only to an extremely limited extent. As to a system of military roads, surveys show that requirements are met by the present carefully planned system of public roads. The need here, as for commercial traffic, is in express roads through metropolitan areas to serve the requirements of industrial mobilisation. Military equipment is so designed as not to cause excessive loads, but with some 20,000 existing bridges which are too weak or too narrow for modern vehicles there is the problem of replacing these structures at an estimated cost of £80-million. Federal (or national), state, county, and municipal governments are all concerned in these road problems.

American Railway Engineering Convention

AT the 41st annual convention of the American Railway Engineering Association, held at Chicago, no spectacular matters or controversial new specifications were submitted, but a number of important subjects were revised or completed—especially in the development of the Association's "Manual of Recommended Practice." In particular, the Committee on Economics of Railway Location and Operation revised and completed its report on the calculation of power of locomotives—steam, electric, and oil-electric. As to length of freight trains, the handling of trains of 110 to 150 cars—average length 40ft.—is practicable and economical, but a great deal depends upon the condition of the engines and track, the performance of the engine crews, the location of passing sidings, and other local conditions which may make the handling of such trains undesirable or impracticable. As to the effect of inland waterway transportation upon the economics of railway operation, it was pointed out that government should consider all methods of transportation on an equal footing and should develop waterways only when and where existing methods are inadequate and waterways can be profitably used. Private enterprise, of course, does not and cannot develop waterways, and any subsidising of water carriage at the expense of rail carriage is unfair competition. The same argument applies to the policy of the Federal and State governments in subsidising highway transportation to the detriment of the railways and their investors. As to the economics of improving railway working by line and gradient revision, or the use of more powerful engines, the result should show a profit sufficient to pay a net return of 15 per cent. on the cost of the improvement.

WATERWAYS AND HARBOURS

Car-ferries or train-ferries were referred to by the Committee on Waterways and Harbours, which described some of the forms of landings used where changes in water level have to be provided for. It also recommended the inclusion in the "Proceedings" of an extended report by E. E. R. Tratman on American and foreign car-ferries. A subject of considerable practical and economic importance is the substitution of outlying freight yards for those in congested city situations where land values are high. A conclusion presented by the Committee on Yards and Terminals is that if the latter or existing facilities are still convenient for rapid service to industries and connecting roads, any change should be considered with caution. In several cases, such proposed changes have not been proceeded with after a study of pros and cons. In other cases the changes have been made and justified, though not always realising the expected reduction in operating costs. Methods and equipment for changing wheels and bogies in coach yards and engine houses were also discussed, including pits for dropping the wheels, and cranes for raising the engines and cars off their wheels. A report on the pitting and corrosion of boilers, by the Committee on Water Service, pointed out that tests do not support the idea, once prevalent, that sodium sulphate in the water will stop embrittlement or "intercrystalline corrosion." No inorganic salt or combination of such salts has been found suitable for the purpose, but organic materials such as sulphite liquor and quebracho are more successful. The boiler manufacturer must take some responsibility in seeing that the design keeps cold working stress at a minimum, and that the seams are so constructed as to be absolutely tight.

RAILS

Further study of the controlled cooling of rails in its relation to the soundness of metal was reported by the Committee on Rails, and this study is still in progress at several rail mills. Other subjects are bend tests in place of the usual drop tests, and both field and laboratory tests on the battering of rails having hardened ends. For the field tests, 900 joints in 131 lb. rails are under observation; 400 have the ends hardened by four different mill processes, 400 have the ends hardened by four different field methods —100 each, and 100 are left without hardening for purposes of comparison. Continuous welding of rails is also under observation. Other field tests in 1939 were concerned with the possible slipping and spinning of engine driving wheels at high speeds. Two methods of making ballast more permanent are to lay it on a base slab of concrete, and to make it waterproof. The latter method, reported on by the Committee on Ballast, includes the use of asphalt-coated broken stone tamped in place by pneumatic tools and covered with a 2in. sealing coat of asphalt and ¾in. stone. This has been laid experimentally on a high-speed heavy traffic stretch of main line. Ties—or sleepers—are now generally 7in. by 9in. in section and 8ft. 6in. in length. The Committee on Ties suggests that a spacing of 10in. in the clear is sufficient for tamping, and that increased bearing may be obtained by ties up to 12in. wide and 8½ft. or 9ft. long, with this spacing. A variety of subjects presented by the Committee on Track included the string-lining of curves, the proper tension on joint bolts, the welding of manganese-steel castings, spirals for high-speed curves, and specifications for track tools and high-carbon tie-plates or base-plates under rails.

TRACK

For track work, the Committee on Track submitted specifications for the proper laying of rails, while the Committee on Maintenance of Way Work Equipment discussed petrol-operated tampers or ballast rammers and the use of concrete vibrators, sand-blasting apparatus and track-welding apparatus. Of larger equipment, there was a report on rail loading and unloading machines, operating either on or off the track, the latter having advantages in keeping clear of trains. Important advantages in the conduct of maintenance work have attended the modern system of interposing supervisors between the section foremen—or gangers, and the roadmasters, or permanent-way inspectors. Track sections were increased from 7 or 8 miles to 10 or 12 miles; and roadmasters have their territories lengthened from 100 to 200 miles, while each supervisor had 60 to 70 miles, or 6 to 7 sections. The number of labourers is less and there is an appreciable financial saving. Supervision of the daily work is closer, and the roadmaster has more time to give to such important work as rail laying or re-ballasting. Similar advantages and economies attend the more careful organisation of bridge repair gangs and their equipment with modern appliances and power tools. With modern heavy track, also, there is less necessity for frequent inspection. Of railways having 164,000 miles of line, 40 per cent. have inspection weekly, 30 per cent. on working days only, 20 per cent. daily and 10 per cent. three times per week.

STRUCTURES

An interesting and instructive, if somewhat disconcerting, feature of the report of the Committee on Iron and Steel Structures, was a series of sketches and brief descriptions of faulty details in existing bridges. These defects were not such as to endanger safety, but rather to cause unnecessary maintenance and repair expense. One example was a truss bridge in which the plate-girder floor beams were notched to clear the flange on the bottom chord or boom. The detailer evidently saw this as an obvious simple way of fitting the floor beams to the truss posts, but it resulted in incipient cracks in the web plates. Specifications for asphaltic compositions as wearing surfaces for wood floors of highway bridges over railways were presented by the Committee on Wood Bridges and Trestles, whose report also discussed the use of modern metal "connectors" for fastening the members of timber structures, as supplements to the usual bolts. And the subject of bridges was rounded out by the Committee on Masonry, whose report covered the design of box abutments for railway bridges over highways; they are monolithic structures including the abutment, curb pier, deck slab over the footway and the footings. This report also discussed a variety of attachments for fastening rails to the concrete floors of unballasted bridges.

SIGNALLING

As a recent development in railway signalling the Committee on Signals and Interlocking noted the introduction of the coded track circuit 11,000ft. long, which by the use of different frequencies can give three or four signal indications without line wires, and can be operated either by primary or storage battery. Developments in the use of electricity in railway service, as noted by the Committee on Electricity, include extensive applications of the fluorescent lamp for lighting passenger cars, and of air-conditioning equipment on cars. It was suggested, also, that with the development of many large hydro-electric projects and the steady growth of transmission lines, the railways will share with industrial and rural consumers the extended use of electric power.

The Association, with approximately 1900 members, carries on its work through the medium of some thirty committees. In addition to its Manual of Recommended Practice it issues a set of drawings of standard designs of switches, frogs, crossings, and other track material. Mr. George S. Fanning, chief engineer of the Erie Railroad, was elected President for the year 1940.

THE CORPS OF ROYAL ENGINEERS.—The War Office announces that His Majesty The King has been pleased to approve of the appointment of Lieut.-General Sir Ronald Charles, retired, Colonel Commandant, Royal Engineers, as Chief Royal Engineer of the Corps of Royal Engineers, with effect from April 23rd, 1940, in succession to General Sir Bindon Blood, who has resigned the appointment. The creation of the Office of Chief Royal Engineer in October, 1936, restored to the Royal Engineers an old military appointment, originally styled "Chief Engineer of the Kingdom," which had existed from the Restoration down to its abolition in 1802. The holder of the appointment is titular head of the Corps, and thus speaks with authority on questions of regimental importance as does the Master Gunner, St. James's Park, in the case of the Royal Artillery. General Sir Bindon Blood has been associated with the Corps of Royal Engineers since 1860. He is the senior Colonel Commandant of the Corps.

Development in Design of Boilers and Boiler House Auxiliaries*

By A. POLLITT, M.I. Mech. E.

(*Continued from page 406, April 26th*)

COAL AND ASH HANDLING

The design of the plant will depend largely upon whether the coal is sea or rail-borne. In broadcast terms, the main difference between the systems is, of course, that a station dealing with rail-borne coal has to be provided with tippler mechanisms to unload the trucks, whereas plants dealing with sea-borne coal have to be provided with jetties, wharves, and coaling cranes. Once the fuel has been delivered on to the belts, the distribution system to the boiler bunkers may be generally similar.

The importance of providing ample coal storage facilities to give the necessary flexibility between the rate of supply and consumption has long been realised, and in addition to momentary differences, such stores enable a reasonably constant fuel supply to be taken all the year round in spite of the considerable variations in consumption as between summer and winter loading conditions. A further advantage is that they safeguard against the possibility of temporary or prolonged interruption of supplies, such as may arise from fogs, coal strikes, or, in these unfortunate days, war conditions.

At the Battersea Power station a coal store of 70,000 tons has been provided and with the designed final installed plant capacity for this station of about 550,000 kW, the fuel consumption (with Welsh fuel) at 55 per cent. load factor would be of the order of 965,000 tons per annum, so that this storage is equivalent to about 37 days' supply, based on the *average* consumption rate.

At the Deptford stations a coal store of about 45,000 tons has been provided, and with a plant installed capacity for these two stations of about 367,000 kW, the fuel consumption at about 32 per cent. load factor would be about 650,000 tons per annum, so that this storage is equivalent to about 25 days' supply based on the *average* consumption rate.

The frequency with which unloading operations have to be carried out is, of course, dependent upon the times of arrival and departure of the colliers, which in turn is largely determined by the tides. The frequency of other coaling operations is determined by the capacities of the boiler bunkers and it goes without saying that in general principle it is an advantage to have as large a capacity as possible, thereby enabling the boiler bunkers to be charged during normal day shift.

In the case of the first six 312,000 lb./hr. boilers at Battersea an individual bunker capacity of about 700 tons was provided, and as the coal consumption (with Welsh fuel) at maximum load is about 13¾ tons per hour, this gives about 50 hours' capacity. However, as original power stations are extended and larger boiler units are installed, it is not always possible to increase the bunker capacities in the same ratio, due to the limits set by the building, with the result that the "time capacity" tends to become reduced. This is a problem which is constantly occurring in older stations in which small boiler units are being replaced by units of much greater evaporative capacity within the same space.

FEED PUMPS

Of all the auxiliaries in a power station the boiler feed pumps are by far the most important, being vital to the safety of the boilers. They also absorb the greatest percentage of the auxiliary power and hence particular care must be taken in the design, both from the point of view of reliability and economy. Their size and power absorption are almost directly proportional to the operating steam pressure.

It is usual to provide two feed pumps for each prime mover, each pump being capable of easily handling the whole of the feed water from the unit under maximum load, with some margin to cover for variation in steam conditions and sudden emergency demands of the boilers. It is also normal to arrange for one pump in each pair to be motor-driven and one turbine-driven.

In calculating the pressure to be generated by a feed pump all the known losses, such as friction through pipes and feed water heaters, loss through feed water regulator, pressure drop through economiser, &c., &c., must be taken into account and must be added to the static head and the pressure in the boiler drum.

In connection with the latter it is not only necessary to consider the normal working pressure in the drum but also the pressure at which the safety valves lift, for it is essential that the pump should be able to continue to feed the boiler even under the worst combination of conditions. By taking margins both in respect of capacity and pressure it will be found that the rated duty of the pump is invariably much greater than the normal duty which it is called upon to perform, and it is necessary, therefore, in fixing the duties to consider very carefully the performance characteristics of the unit, and whilst it is essential that the pressure-volume characteristic should be

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* Abstracts from a paper to the Manchester Association of Engineers, February 23rd, 1940.

such that the maximum calculated pressure is generated at the maximum water quantity, yet it is desirable that the peak of the efficiency curve should occur at a somewhat lesser quantity, at which the pump is likely to operate during the majority of its working life.

The fact that by making allowances and margins for various abnormal contingencies the pump is somewhat "oversize" has to be accepted from a consideration of the importance of the safety of the boilers under emergency conditions, for which a certain amount of efficiency under normal conditions has to be sacrificed. In an endeavour to reduce this loss in certain cases variable-speed drives have been adopted, the speed being regulated according to the pressure in the feed mains.

In reference to this question of characteristics it cannot be over stressed that all pumps must have a pressure-quantity characteristic which rises continuously from full duty quantity to zero quantity in order to ensure satisfactory parallel operation between groups of pumps operating on the same feed system. There is much to be said for having all pumps of the same general design and running at the same speed in order to attain this end.

One development which has occurred in recent years, more particularly in connection with E.H.P. boilers, is the introduction of reciprocating feed pumps, typical examples of these being the pumps associated with the 150,000 kW set in the State Line station of the Commonwealth Edison Company at Chicago, and those associated with the Loeffler boiler installation at the Brimsdown "A" station of the North Metropolitan Electric Supply Company. On a recent visit to America the author had occasion to see the former pumps and the size and space occupied were tremendous compared with that required for an ordinary centrifugal pump for the same duty.

The advantage of the reciprocating type of pump is that it has a very high efficiency, but the disadvantages are its high cost, weight, and space requirements and the possible danger to the feed mains due to the intermittent delivery which it is difficult completely to damp out even with the provision of steam generating receiver systems.

An interesting development which may see the light of day in the near future is the designing of a high-speed reciprocating pump which overcomes many of the disadvantages associated with the older slow speed type.

MATERIALS OF CONSTRUCTION, PIPE FLANGES, &C.

(*a*) *Materials.*—Whilst materials for engineering construction are always gradually improving in quality and properties, it is those which are required for withstanding higher steam temperatures, such as for superheaters, steam pipe lines, and the high pressure ends of turbines, which have received the greatest attention in recent years due to the drive towards higher operating temperatures.

For many years temperatures were limited to about 750 deg. Fah., but as soon as the thermal advantages of exceeding this figure were appreciated metallurgists concentrated much attention on the problem, with the result that working temperatures rose to 800, 850, 900, and now to 965 deg. Fah. Not only was it necessary to develop materials which were able to give satisfactory ultimate tensile stresses at these higher temperatures, but also to withstand "creep," a factor which did not have to be considered with the lower temperatures. Also, the question of oxidation came into prominence as temperatures were increased.

In the case of superheaters, experience shows that those portions operating up to a temperature of 800 deg. Fah. can be satisfactorily manufactured in mild steel provided that the steam velocities are kept well up and even distribution is attained. For the range 800 to 850 deg. Fah. a straight low carbon molybdenum steel is generally agreed to be most satisfactory.

Above 850 deg. Fah. it is necessary in order to avoid oxidation, as well as to provide the creep resistance, to use somewhat more complex alloys, such as chrome-molybdenum or silicon-chrome-molybdenum steels. In U.S.A. considerable prominence has been given to the use of ½ per cent. molybdenum, 4 per cent. chrome steels, the former conferring the necessary creep properties and the latter the resistance to oxidation. However, experience in this country appears to show with this high percentage of chromium the creep properties suffer, being less than that of the straight ½ per cent. molybdenum steel, and furthermore, a somewhat "dirty" steel results. For this reason it is more usual here to limit the chromium to about 1 to 1¼ per cent.

Another alloy which has been brought forward recently is a molybdenum-vanadium steel for which high creep properties are claimed, particularly at temperatures above 950 deg. Fah., but sufficient actual operating experience has not yet been gained definitely to state whether this has any advantages over the ½ per cent. molybdenum, 1 per cent. chrome steel.

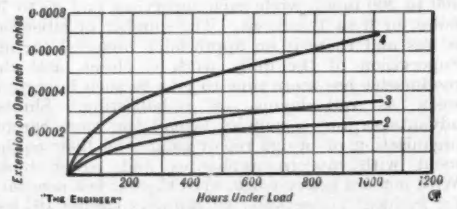
There are, of course, many other complex alloys, such, for example, as the well-known 18 per cent. chromium, 8 per cent. nickel steel, but the cost of these is so high that it is preferred to use simpler alloys if possible.

In considering the suitability of alloys for various working conditions the determining factor is, of course, the metal temperature, and whereas in the case of superheater tubes the metal temperature will be greater than the steam temperature within the tubes, yet in the case of steam pipes the metal temperature will be less than that of the steam.

Even though somewhat more complex alloys are required for superheater tubes for high steam temperatures due to the question of oxidation, it appears that a straight low carbon molybdenum steel is satisfactory for the steam pipes for these steam conditions.

The physical properties of materials are determined not only by the chemical constituents, but also by the heat treatment, and depending upon the use to which the material is to be put so will it be heat treated to give those particular physical properties which are considered necessary, *e.g.*, high tensile strength, high creep resistance, high impact value, &c., &c.

As a matter of interest, Fig. 7 shows some general particulars of alloys which are at present being used



Reference	1	2	3	4
Description of steel	0·2 to 0·25 per cent. straight carbon steel	0·2 to 0·25 per cent. carbon 0·6 to 0·7 per cent. Mo. steel	0·25 to 0·35 per cent. carbon 0·45 per cent. Mo. steel	0·4 to 0·45 per cent. carbon 0·7 to 1·00 per cent. Mo. 1·30 to 1·50 per cent. Cr. steel
Ultimate tensile strength, tons/sq. in.	28–32	30–36	45–55	65–75
Yield stress, tons/sq. in. ...	14–16	15–18	27	56–65
Elongation of 2in. per cent.	25	25	22	17
Reduction of area, per cent.	40	40	45	40
Impact value, ft. lb.			20	35

Creep Properties

Reference no.	Temperature	Load	Creep rate
	deg. Fah.	Tons/sq. inch	In./in./hr.
1	—	—	—
2	950	5	$0{\cdot}54 \times 10^{-7} = 0{\cdot}000000054$
3	950	5	$1{\cdot}37 \times 10^{-7} = 0{\cdot}000000137$
4	950	5	$3{\cdot}3 \times 10^{-7} = 0{\cdot}00000033$

Fig. 7—*Physical Properties of Typical Steels*

extensively in this country in connection with modern high temperature installations.

(*b*) *Pipe Lines and Flanges.*—The introduction of higher steam pressures and temperatures has influenced very considerably the design of steam piping systems, and it has seen the introduction of the "all-welded" lines. The latter has been developed more particularly in the U.S.A., where it has been extended not only to intermediate pipe joints, but also to the valves and fittings to be mounted in the lines and to the terminal connections as well.

In this country, whilst welded pipe-to-pipe joints are being adopted in latest steam plants, it is still felt advisable to use flanges for valves, fittings, &c., and at terminal points.

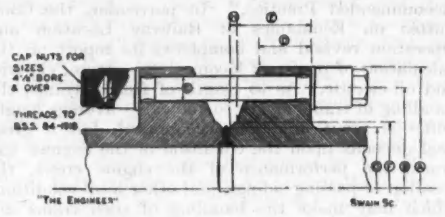
Turning to the question of flanges, as steam temperatures are increased the maximum operating steam pressure for which a given flange is suitable decreases, as may be seen from Table IV, which refers to the various British Standard Pipe Flange Specifications. No British standard exists for a combination of 1420 lb./square inch and 965 deg. Fah., which was selected for the Battersea "B" station. For this reason it was necessary to design a completely new range of flange standards to suit these conditions and the particulars of the flanges finally evolved are shown in Fig. 8.

TABLE IV.—*Maximum Working Pressures for various British Standard Pipe Flange Tables at Different Steam Temperatures*

Steam temperature, deg. Fah.	800	900
Maximum steam pressures for flanges in accordance with :—		
Table "T," lb./sq. inch	1400	900
Table "S," lb./sq. inch	900	600
Table "R," lb./sq. inch	600	450
Table "K," lb./sq. inch	450	350

At the time that these flanges were designed no experience was available of operation with E.H.P. steam at temperatures as high as 965 deg. Fah., and for this reason the scantlings were made very heavy so as to reduce the stresses in the flange assembly to figures below that at which it was anticipated that creep would be excessive. It was considered wise, in addition, to make provision to guard against the possibility of trouble still being experienced and the designs are therefore laid out so as to enable the joints to be made in four different ways.

In the first instance it is proposed to make a plain serrated ring joint, but if after a short time of operation a slight leakage becomes evident, it will be



Pipe size bore	O.D. flange	P.C.D	No. of Bolts	Dia. Bolts	Thickness of flange		Facing		
					out-side	in-side	Gross	Net.	Thick-ness
	A	B		C	D	E	F	G	H
2	8½	6½	8	⅞	1½	2½	4½	3½	⅛
2½	9½	7½	8	1⅛	1½	2½	5½	4½	⅛
3	10½	8½	12	1	2½	3½	5⅞	4⅞	⅛
3½	11½	9½	12	1⅛	2½	3½	6½	5⅜	⅛
4	12½	10½	12	1¼	2½	4½	6⅞	6	⅛
4½	13½	11½	12	1⅜	3	4½	7½	6½	⅛
5	14½	12	12	1½	3½	4½	7½	7½	⅛
6	17	14	12	1½	3½	5⅞	9½	8½	⅛
7	18½	15½	14	1¼	4½	6	10½	9½	⅛
8	19½	16½	14	2	4½	6½	11½	11	⅛
9	21½	18	16	2	4½	6½	13	12½	⅛

All dimensions in inches

Fig. 8—*Pipe Flange Particulars for Extra High Pressure and Temperature Steam Lines*

possible to weld seal the joints on each side of the serrated ring in the grooves formed between the serrated ring itself and the projecting faces of the flange which have been designed particularly with this end in view. Should seal welding prove unsuccessful it will be possible to remove the serrated ring altogether and whilst still using a bolted joint to provide a heavy seal weld directly between the two adjacent faces of the flanges.

As a fourth alternative, a groove has been provided in way of the bore of the pipe adjacent to the flange face to enable a diaphragm type of joint ring to be used, the two halves of the diaphragm being welded into these grooves and the tip of the diaphragm being welded outside. Thus, if the bolts do creep excessively the diaphragm type of flange joint would automatically take up this creep and prevent leakage. In view of the space which would be left by the machining of the groove for this fourth alternative type of joint, it was decided to fill in this space by a ring, as shown in Fig. 8, the purpose of this ring being twofold, first, to maintain a smooth internal surface to the pipe, and secondly to act as a locating ring for the serrated rings.

It may not be necessary to use any of these alternative methods, but it appeared wise in this pioneer installation with high temperature operating conditions to arrange the flange designs so that advantage could be taken of any of the alternative methods available.

These remarks apply more particularly to the larger sizes of flanges and it is because of the possibility of subsequent welding, which has been envisaged, that the flanges are cut back on the faces to give the necessary access for the welding torch.

BOOKS OF REFERENCE

The Water Engineer's Handbook and Directory, 1940. London: Water and Water Engineering, 30, Furnival Street, E.C.4. Price 8s. 6d. net.—The new edition of this valuable little reference book has been thoroughly revised and brought up to date. As in previous years it contains full particulars of this country's water undertakings; water engineers; catchment boards; drainage authorities; reservoirs; institutions; government departments, &c., together with statistics, data, and special articles on rainfall, water engineering progress, and law.

The "Shipping World" Year Book and Port Directory, 1940. London: "The Shipping World," Effingham House, Arundel Street, W.C.2. Price 25s. net.—The new edition of this book has been completely revised and comprises four main sections. The port section gives full details of more than 800 ports in this country and abroad. Another section deals with the ownership of British ocean-going tonnage and covers liner, tramp, and tanker companies owning between them about 14,600,000 tons gross. A "Who's Who" in the world of shipping contains biographical and other particulars of prominent figures in the shipping and allied trades. A new feature of the book is a directory of ship repairers. It also includes a considerable amount of other information of interest and value to those in the shipping industry including a directory of shipbuilders and marine engineers; load line regulations; life-saving appliances and wireless telegraphy rules; Board of Trade regulations; York-Antwerp Rules of General Average; Carriage of Goods by Sea Act; and a sailing ruide of freight and passenger services from British ports.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

The American Steel Market

The situation in the American iron and steel markets has been disappointing and for some weeks production showed a steady decline. This movement appears to have been checked and strong hopes are entertained that production for the second quarter of the year will be between 60 and 70 per cent. of capacity. The rate of output, however, has fluctuated during recent weeks and now stands at about 61 per cent. Irregularity in the production in the various districts is noticeable. For instance, whilst the average for the trade is 61·7 per cent., the works in the Birmingham district are operating at 81 per cent., and an important independent steelworks has maintained production at 75 per cent. of capacity. This result is attributed to the excellent geographical situation of the works in question in relation to the most active markets. The buying of pig iron which has been unsatisfactory for some time appears to be improving and in the Birmingham district has been in excess of the productive capacity. As a consequence the furnaces there are operating at about 98 per cent. of capacity. On April 1st out of 233 furnaces in the United States, 151 were in active operation. It is said that stocks are being reduced by shipments against customers' specifications from a number of idle furnaces. If this process is continued it would not be surprising if there were a revival of active buying. The consuming industries, however, are not busy, the ironfoundries averaging only five days per week. The cast iron pipe foundries are in a somewhat better position. Operations at the tinplate mills have considerably improved and rule at about 62 per cent. of capacity. The revival in activity has been largely the result of the extensive buying of tinplates for export. The situation in the galvanised sheet section of the market has not improved and operations have fallen to 48 per cent. Observers are optimistic and claim that there are indications of improved buying of a general character. The orders for structural steel are less than those of 1939, although recently they have shown a slight improvement. For the first three months of the year the total was 243,500 tons, compared with 305,000 tons for the corresponding period of 1939. American manufacturers are turning their attention to exports with increasing vigour. Amongst recent inquiries is one from Brazil for 45,000 tons of rails, whilst the Iran State Railway has inquired for 12 locomotives, and this number may be increased to 24. Domestic purchases include the New York Central Railway's order for 50 heavy freight locomotives and 1500 hopper bottomed all-steel freight cars of 50 tons capacity. It is suggested, however, that the use of light weight steel and of weight saving alloy steel will reduce the total required for the manufacture of this rolling stock. In an order for 6000 freight cars placed by an American railway 3000 tons was saved by the use of this class of steel.

The Pig Iron Market

The demand for pig iron is expanding as more of the consuming establishments are put upon war work. This applies particularly to foundry descriptions since the demand for basic and hematite has for some time been at a level which has taxed the resources of the producing works. Business in high phosphoric foundry, however, has been quiet since the outbreak of war largely because the light castings foundries have been working short time as a result of the poor demand for their products from the building trade. Recently efforts have been made to obtain a share of war work for this industry, and at the same time it is suggested that the unemployed plant of the light castings makers might usefully be put upon the production of goods for export. Whilst there has been no general movement in these directions it would appear that some at least of the light castings foundries are busier than they have been for months, and this activity is reflected in a rather better demand for high phosphoric foundry iron. There is no lack of supplies of this description since production has been in excess of the demand and the improvement has been welcomed by the makers. Low phosphoric iron has been in active request since the beginning of the war, as it is a material largely used by engineering firms and motor-car makers. The stocks of this iron at the producing works were depleted some time ago and although the output has been slightly increased it is scarcely equal to consumers' requirements. It is expected, however, that a further expansion will be effected in output during the coming weeks. The steelmakers' requirements of basic iron have also expanded of late, and although there have been distributions of imported basic the situation is not entirely satisfactory. British pig iron producers have concentrated so far as possible upon the production of this description which now reaches a huge weekly tonnage. It is not, however, adequate to meet the full demands of the steelmakers and it is expected that further important quantities will be brought into the country. No concern, however, need be felt with regard to future supplies. The output of hematite iron is understood to have improved of late, and although stocks at the furnaces have practically disappeared the current production seems sufficient to meet consumers' demands. Large quantities are being taken up by the steelmakers and also by some engineering firms who are experiencing difficulty in obtaining their full requirements of low phosphoric iron and use hematite as a substitute.

The Midlands and South Wales

All the steelworks in the Midlands are working at capacity and are struggling to meet the ever increasing demand. By far the greater part of the business upon which the works are engaged is for Government account, but a number of export orders have recently been accepted. In practically every instance the steel works are unable to quote for reasonable delivery periods, although now consumers are sustained by the hope that the new distribution scheme will restore some regularity in this respect. The scheme is gradually taking shape, but it will be some time before it is in full operation. The continual expansion in the requirements of the Government, however, have led to the fear on the part of those users who require material for work other than national purposes that they will be no more likely to obtain their needs under the new scheme than they were under the licensing system. Efforts are continuously being made to increase production; but at the majority of the works it would seem that the peak has been reached. Consumers continue to press for supplies, and in particular the structural engineers require large tonnages since they have heavy contracts in hand which will keep them employed for several months. In fact the programme of expansion in the way of Government buildings and additions to factories, &c., shows no signs of becoming restricted. The quantities of structural steel passing into consumption reaches an astonishing tonnage and the needs of the shipyards are scarcely less than those of the constructional firms. The Admiralty building programme of naval and merchant ships has not yet reached its full dimensions, but, nevertheless, practically every shipyard in the country is occupied to capacity. The pressure to obtain plates of all thicknesses, and particularly the heavy and medium descriptions is unabated and there is little room for any business but that arising from the war effort. The sheet makers are turning out large tonnages, most of which are for one or other of the Government Departments, although a certain tonnage is also being released for export. At the same time attempts are being made to work off the old contracts which are on the makers' books. In South Wales the steel industry is operating at full pressure but the tinplate works, as well as the sheet makers, complain that they are unable to obtain their full supplies. Nevertheless, the situation is better and appears to be improving. The export demand for tinplates has declined somewhat but is still active. The sheetmills also are busy, but as in the tinplate industry the makers are clamouring for larger supplies of steel. The requirements of the shipyards in South Wales are heavy and the constructural engineers are also making heavy demands upon the structural steel makers.

The North-East Coast and Yorkshire

Extreme activity prevails at the steelworks on the North-East Coast, but so great is the demand that little impression is being made upon the orders which have accumulated on the makers' books. Most of the works are in arrears with deliveries, although every effort is being made to meet consumers' urgent requirements. It will be some weeks before the new distribution scheme is in thorough working order and the steelmakers are awaiting with some anxiety the forthcoming allocations of steel. It is realised that the works will in future be prevented from accepting orders in excess of their capacity to deliver, and whilst this should give assurance to consumers of regular deliveries to time it will probably mean the latter's requirements will be cut down. Since it is believed, however, that the practice has grown up of users ordering beyond their absolute needs, this may help in improving deliveries. All the big steelworks on the North-East Coast are turning out a huge tonnage of structural steel which is taken up immediately by constructional engineers, shipyards, and many other industries. It is probable that the production of this class of material has reached higher levels than ever previously attained. The big Government programme of new works and extensions to existing plant absorbs large tonnages of joists and sections, and the extensive shipbuilding programme also requires large supplies of steel. The plate mills are fully occupied, and orders are accumulating, the demand for this material being exceptionally strong. Few of the re-rolling works are in a position to accept new business, so heavy are the orders already in hand. Their position, however, is better than for some time past owing to the distribution of considerable tonnages of semis. The demand for sheets appears to have grown during the past week or two, but most of the production is earmarked for Government purposes and although there is a large inquiry for commercial work, this class of users have to wait a long time for the execution of their orders. The Yorkshire steel works are operating at capacity. The basic steel producers are experiencing great pressure from consumers and are struggling to avoid accumulating further arrears, which at the moment are considerable. The Sheffield works are pressing forward the production of special and alloy steels for which there is an insistent demand. Business in stainless steel is active, but the stringency of the low carbon grades of ferrochrome may adversely affect outputs.

Copper and Tin

The copper consuming industries in Great Britain continue to take large tonnages of the metal; but there does not appear to be any stringency and so far as can be seen users are obtaining all they require as and when they need it. At the same time it is not considered advisable to release much copper for commercial work, and as a consequence there has not been much export business transacted. In the case of an imported metal such as copper it is probably thought advisable to retain considerable stocks in this country. The world market has become quieter and prices have shown a tendency to weaken. The producers, however, maintain the domestic price of 11·50 c. although the export quotation has slipped back to 11·37½ c. f.a.s. It is suggested that one reason for the easier prices is that the American deliveries during March were rather disappointing. It is pointed out, however, that too much attention should not be paid to this since it is a characteristic of American buyers to go to extremes, and to buy more than they require for a short period, afterwards living on their stocks for a time. Neutral buying in the United States has been on an extremely quiet scale. The Americans require payment before shipment and to this consumers in neutral countries are reluctant to agree. At the same time the recent extension of the war to Scandinavia and threats in other quarters have made the Americans the more determined to insist upon these terms. . . . Whilst the London tin market has been rather dull the Eastern price has risen. This was largely the result of some American buying which, however, was not sustained. American consumers appear to be fairly well covered and show little disposition to enter the market on any substantial scale and this has largely accounted for the weaker prices which have been in evidence in this market. In Great Britain the trade is hampered by the difficulty of obtaining export licences, but on the other hand this should result in the accumulation of British stocks, which had fallen to a low level. It cannot be said that the stocks are dangerously light, but they are certainly not heavy considering that we are living in a time of crisis. Prices are regarded as being reasonable, but it is thought that the backwardation is unnecessary. Consumption continues on a good scale and the market remains of the opinion that prices must go higher when the International Tin Committee's drastic cut in export quotas begins to take effect.

Lead and Spelter

The war requirements absorb large tonnages of lead, but the supplies reaching this country appear fully adequate to meet the demand. Important schemes of construction for the Government are in hand, or about to be commenced, and these will probably account for even larger quantities than are now being used. The makers of lead products are finding practically their whole output taken up on Government account, but in certain cases there would appear to be some surplus plant, and the producers have been pressing the authorities for lead to manufacture exportable products. Apparently, however, it is not thought wise to use lead held by the Control for this purpose, and the suggestion has been put forward that it might be worth while purchasing additional quantities of either Empire or foreign lead to enable manufacturers to produce for export. Probably there will be objections to this course and in any event it is doubtful if the amount of surplus plant available would prove to be very important. . . . The situation in the spelter market shows little change and one of the most satisfactory features is the volume of supplies which is reaching this country. Although there was a slight stringency noticeable in the market a few weeks ago this has entirely passed and consumers now appear to be assured of deliveries as they are wanted. Reports have been current that the invasion of Norway has stopped some imports reaching us from that country. It was understood that all supplies to Great Britain from the commencement of the war came from Empire sources, but it is possible that private firms had contracts with Norwegian smelters when the war broke out, which were afterwards taken over by the Control. It is unlikely, however, that the quantities involved were large. The demand from the consuming industries is undiminished. The galvanisers are taking considerable quantities and are likely to continue to do so for some time to come. The brassmakers also are exceptionally busy. This industry has received a considerable amount of inquiry lately for brass products for export, but British makers have not found it possible to supply the material since all available plant is occupied upon war work. Inquiries in the United States for brass have not led to much business since the American quotation is considered too high.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

BRITISH STANDARD VOLTAGES

(B.S. 77).—Since the publication in 1932 of the third edition of this British Standard, the development in A.C. transmission and distribution has brought about considerable changes in practice, and the revised edition of B.S. 77, recently issued, takes account of this progress. The chief change between the old and revised specification is the substitution of two standard voltages—"system voltage" and "declared voltage" for the four voltages included in the 1932 edition. System voltage is defined as "the voltage between lines for which the system is designed and installed," while the "declared voltage" is "the voltage at the consumer terminals declared by the undertaker." In the interests of general standardisation, the specification is not now confined to new systems. A revised list of standard voltages is given. Copies of this British Standard can be obtained from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1. Price 1s. each (1s. 2d. post free).

STEEL TUBES FOR WATER WELL CASING

(B.S. 879).—This specification applies to lapwelded and weldless tubes of nominal diameters from 4in. to 48in. with two types of screwed joints, namely screwed and socketed (with V or square form threads) and with flush joints inside and out with square form threads. The quality of the steel is determined by tensile bend and flattening tests, whilst flattening tests are also included to determine the quality of the weld. Hydraulic test pressures are prescribed, and general requirements are included in respect of the accuracy of the alignment of joints, of coating and oiling of tubes, and of packing for transport. Fully detailed requirements are given for the dimensions of the tubes and sockets and their screw threads.

French Engineering Notes

(From our own Correspondent in Paris)

Armament Production Methods

WHEN Monsieur Dautry, Minister of Armaments, visited London and made a tour of armament factories in Britain he invited Mr. MacLaren, General Director of Arsenals, to visit France and see what was being done in this country. A knowledge of the way in which the two countries work for the common defence is obviously to the advantage of both of them. It was desirable that there should be an interchange of visits not only among the heads of arsenals but also among workers and technicians, and six British foremen therefore came to France to learn something of the conditions of work and the methods employed. On returning home they gave so favourable a report that Mr. MacLaren fulfilled his promise to Monsieur Dautry to see for himself what was being done for the production of armaments. At the close of his visit to arsenals and works Mr. MacLaren said that he had been greatly impressed with all that he had seen, particularly the intense and concentrated effort observable everywhere, the work done by women which, he said, he could hardly have believed possible, and the successful training of men and women at all the works he had visited. The thing that struck him most of all was the manner in which excellent work was being done on products that would normally require more modern and special machines. This observation points to a characteristic of French technicians and skilled workers who were formerly brought up to adapt machine tools for special work for which they were not primarily intended. In a general way, there was then too much economy in the equipment of engineering shops, and owners were not always willing to spend money on modern machine tools so long as they could make use of the machines they had. A good deal of ingenuity was needed to equip machines for special work with satisfactory results. The necessity for making the fullest use of all machine tools that are requisitioned for armament production has brought out the old skill in improvising methods, and this will continue to be done so long as the supply of modern machines does not keep pace with the needs of an increasing production of war material. Mr. MacLaren declared that British and French technicians could learn much from each other, and he intended to send members of his technical staffs to France to study details of manufacturing methods that he had seen during his visit.

Stabilising Prices

The methods adopted by the Price Control Commission to prevent an inflation of prices have not proved generally satisfactory. They are based on the only safe principle that prices must remain at the level at which they stood on September 1st last, and these prices are revised by the Commission if justified by higher manufacturing costs or by increases in the values of raw materials. Applications for advances are made by syndicated groups representing the different branches of industry. If the applications are granted the groups circularise their members, usually with no other publicity, so that consumers are bewildered with rising prices of which they have no explanation except that the advances are officially authorised. It cannot be said that advances are abnormal in the circumstances, but there is a fear of possible inflation which must be avoided at all costs. The Control Commission has exercised extreme caution in dealing with a difficult situation. Overhead production charges have increased, and nothing is allowed for exceptional depreciation of machinery and plant which will have to be renewed after the war. The advances in iron and steel prices, and the still greater increases in values of imported raw materials, brought in their train a steady rise in the prices of manufactured goods. The Control Commission and the Ministries concerned have come to the conclusion that the tendency towards inflation must end. They argue that factors which increased manufacturing costs soon after the war have produced their full effect and the situation does not become worse, while prices of imported raw materials have not further increased and have, in fact, become easier. Consequently, it has been decided that from the end of April no more applications for price advances will be considered for a period of three months. A reason for stabilising prices in this way is probably a belief that the Anglo-French agreement has put an end to any risk of inflated prices for raw materials, which should settle down to a normal level. The uneasiness that has been growing among consumers who feel that they have no voice in the matter is allayed by their being invited to notify the Control Commission of any apparent unauthorised increase of selling prices. Complaints of unfair treatment are made by some manufacturing groups who have waited too long in applying for what they regard as justifiable increases, but the Control Commission will probable take special cases into consideration so as to be sure that stabilisation is effected in a fair and equitable manner. The three months' trial will show whether the experiment is satisfactory and can be continued.

Paid Holidays

Owing to serious inconveniences caused by limiting the holiday period to two months, it was decided last year to extend it over three months, and those workers who were to have taken the first two weeks in September had no holidays at all. This year the conditions are far more difficult. There is no desire to deprive men of their holidays when the strenuous efforts imposed on them make it more desirable to give workers their fortnight's change and rest. But this cannot be allowed to interfere with armament production. It has therefore been decided to spread the holiday period over the whole year so that men can take their turn at any time when, and if, they can be released. The length of the holiday is counted as one day for each month for men who have been employed in a works for at least four months. It can be split up in two or three parts, one of which must be of six days' duration between two Sundays. The employer will decide whether, and when, holidays can be given, depending upon the national work in hand. When men cannot be allowed holidays they will be indemnified with double pay.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

AERONAUTICS

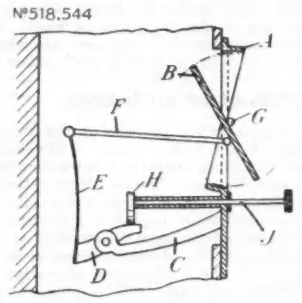
518,874. September 1st, 1938.—AIRSCREWS, the De Havilland Aircraft Company, Ltd., Hatfield Aerodrome, Hertfordshire, and Frederick Metcalf Thomas.

According to the present invention, an airscrew blade comprises a metal part adapted to be attached to a hub and to transmit all forces between blade and hub and forming part of the profile of the blade, and a second relatively less strong part composed of a mass of low-density material of such lightness as to be successfully secured by adhesion to the stronger part, to complete the blade profile. Preferably the form and location of the joining surfaces is such that the metal part of a blade forms the leading edge and the majority of the negatively loaded or forward surface, and the tip; whilst the non-metallic part forms the trailing-edge (except at the tip) and the majority of the positively loaded or rearward surface; and the joining surface lies mainly chordwise in the blade. The joining surface is preferably somewhat sinuous in section line.—*March 11th, 1940.*

FURNACES

518,544. August 26th, 1938.—MEANS FOR CONTROLLING AUTOMATICALLY THE DRAUGHT IN FLUES OF COMBUSTION APPARATUS, Récomatic S.A., 1, Square de Villereuse, Geneva, Switzerland.

The accompanying drawing illustrates by way of example one embodiment of the invention. A flue gas conduit or chimney has a side inlet, in which is set a frame A for pivotally mounting a damper B. On this frame is a bracket arm C extending into the interior of the flue and carrying the hinge of a lever D which, in combination with a bi-metal blade E and a connecting rod F, constitutes the device for controlling the draught of the flue gas. The blade has one end fixed to the lever and the other

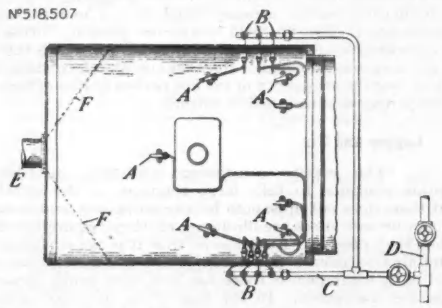


pivotally connected with the rod. The connecting rod is also connected to the damper which is mounted on an axle G across the frame. The weight of the rod and of the blade would tip the lever, which, however, rests with the free end against a cam H fixed to the end of a shaft J. The end of this shaft has, on its opposite end, an operating button and a pointer. The button turns the cam which determines the amount of opening of the damper for a certain curvature of the blade, depending upon the temperature of the flue gas. The aperture is therefore determined for every temperature higher than that for which the damper closes the opening completely.—*February 29th, 1940.*

LOCOMOTIVES

518,507. August 27th, 1938.—EJECTING MEANS FOR ASHES AND LIKE MATERIALS FROM ENCLOSED SPACES SUCH AS SMOKE BOXES, Thomas Wright Royle, Chief Operating Manager, London, Midland and Scottish Railway Company, Euston Station, London, N.W.1, and Percy McCallum, Coundon, Eastbury Road, Oxhey, Herts.

The cleaning out of locomotive smoke boxes is a troublesome and objectionable operation involving much labour and loss of time. One great difficulty to be dealt with is the ability of the heap of fine material accumulating in a smoke box to settle down into a fairly stiff or rigid mass which is capable of sustaining itself even with a hollow or arch formation in its base. Thus, if suction be applied to the base of such a mass, a portion may be withdrawn so that an arch or hollow is formed but this does



not cause the heaped mass to break down. Consequently, the continued working of the suction device fails to effect further ejection unless mechanical means are employed for breaking down the mass. The object of this invention is to overcome the difficulties and provide an apparatus which can be relied upon for effecting a complete ejection of an accumulation of ashes without the aid of mechanical devices. It is illustrated as applied to a railway locomotive smoke box. Seven nozzle fittings A are bolted or riveted to the bottom and around the curved sides of the smoke box. These fittings are connected by pipes each to a respective stop valve B on an adjacent manifold. The manifolds are connected by further pipes C to a pipe which is branched from the injector delivery pipe D. A stop valve is provided in the branch pipe C for controlling the ejecting means. An outlet pipe E for the ejection of the ashes is provided at the front of the smoke box level with the bottom and below the usual inspection door. The nozzle fittings are located and directed so as best to eject the accumulated ashes through the outlet pipe, the location of which is dependent upon the individual characteristics of the particular smoke box. With one or more of the nozzles at work, the ashes and fine material are forcibly carried away from the base of the heap which accumulates towards the outlet aperture, the deflector plates F assisting the side jets in this respect. Owing to the intersection or close co-operation of the jets from the nozzles, it is impossible for the mass of material to support itself upon an arched base and so resist ejection because as soon as a hollow is formed by one jet it is broken down due to the action of an adjacent jet or jets. The mass thus constantly settles down bringing fresh material into the paths of the jets.—*February 28th, 1940.*

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Air Raid Protection Institute

Tuesday, May 7th.—Royal Society of Arts, John Street, Adelphi, W.C.2. "Organisation of the Casualty Services," J. A. Struthers. 8 p.m.

Chartered Surveyors' Institution

Monday, May 6th.—12, Great George Street, Westminster, S.W.1. "The Compensation (Defence) Act, 1939," C. G. Eve. 5 p.m.

Crewe Pupils and Premium Apprentices

Friday, May 24th.—Oddeninos Hotel, Regent Street, W.1. 50th Annual Dinner.

Faraday Society

Friday, May 17th.—Royal School of Mines, South Kensington, S.W.7. Discussion on "The Hydrogen Bond." 2.30 p.m.

Institute of Metals

Wednesday, May 8th.—Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. General Meeting. 2 p.m. May Lecture, "The Cyclotron and its Applications," J. D. Cockroft. 7 p.m.

Institution of Chemical Engineers

Tuesday, May 7th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Measurement of the Flow of Liquids and Gases," E. Ower. 5.15 p.m.

Institution of Civil Engineers

Tuesday, May 7th.—Great George Street, Westminster, S.W.1. "Cliff-Stabilisation Works in London Clay," J. Duvivier. 5.30 p.m.

Institution of Electrical Engineers

To-day, May 3rd.—Meter and Instrument Section. Savoy Place, Victoria Embankment, W.C.2. "Insulation," H. Warren. 6 p.m.

Wednesday, May 8th.—Savoy Place, Victoria Embankment, W.C.2. "Mechanical Integrity in the Design of Electrical Circuit-Breakers," M. C. Hunter. 6 p.m.

Thursday, May 9th.—Savoy Place, Victoria Embankment W.C.2. Annual General Meeting. 6 p.m.

Institution of Mechanical Engineers

To-day, May 3rd.—Internal Combustion Engine Group. Storey's Gate, Westminster, S.W.1. "Operating Experience with Gas Producers." 6.30 p.m.

Iron and Steel Institute

To-day, May 3rd.—4, Grosvenor Gardens, S.W.1. Annual Meeting. 10 a.m. For programme, see page 357.

Royal Institution of Great Britain

To-day, May 3rd.—21, Albemarle Street, W.1. "Symmetry of Patterns," W. L. Bragg. 9 p.m.

Royal Society of Arts

Tuesday, May 7th.—John Adam Street, Adelphi, W.C.2. "Earthquakes and Structures," D Laugharne Thornton. 2.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

Mr. A. T. HOBBS, M. Inst. C.E., has resigned his appointment as secretary of the Diesel Engine Users' Association.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, announces that Mr. H. T. Tilley has been appointed manager of its London engineering department in succession to the late Mr. J. Mercer.

VICKERS, Ltd. announces that in order that he may take up a Government appointment of national importance, Sir Charles Craven has been granted leave of absence from the Vickers group of companies. In consequence the following appointments are being made:—For Vickers-Armstrongs, Ltd., Mr. F. C. Yapp becomes acting chairman, Mr. J. Callander becomes acting deputy chairman; for the English Steel Corporation, Ltd., Mr. F. C. Yapp becomes acting chairman.

CONTRACTS AND ORDERS

THE ASSOCIATED EQUIPMENT COMPANY, Ltd., Southall, Middlesex, has received an order for 50 "Regal" direct injection, oil engined single deck omnibuses to be operated by the Bagdad Metropolitan Transport Board. The order was secured after a considerable period in the face of fierce foreign competition.

CATALOGUES

NEWMAN, HENDER, AND CO., Ltd., Woodchester, Glos.—Catalogue No. 59, describing valves, cocks, and fittings.

RANSOME AND MARLES BEARING COMPANY, Ltd., Newark-on-Trent.—Catalogue of ball and roller bearings for aircraft.

KEITH BLACKMAN, Ltd., Mill Mead Road, Ferry Lane, Tottenham, London, N.17.—Booklet K 189, on dust removal plant.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—Pocket Book for Wiremen, leaflet on B.I. jointing compounds, and catalogue of materials for overhead lines.

HENRY WIGGIN AND CO., Ltd., Thames House, Millbank, London, S.W.1.—Booklet giving an account of the properties, typical uses and fabrication of "Inconel."